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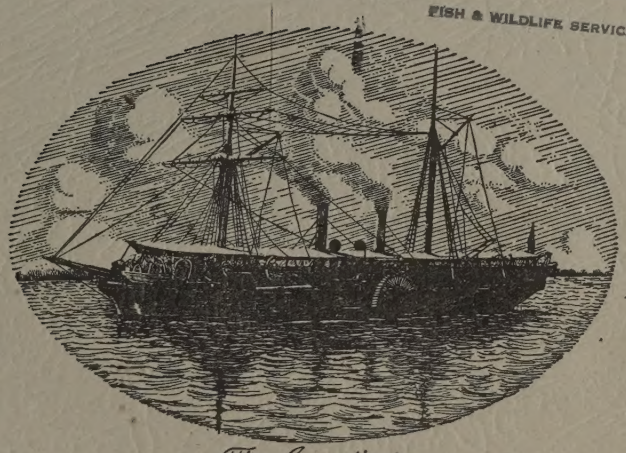

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Scombroids constitute one of the most economically important groups of marine fishes and of these, the mackerel and to some extent the seer fishes form regular fisheries in many areas while the tunas and the billfishes are of potential value with considerable scope for development. Our knowledge about them in general in the Indian region is rather meagre and even the available information is scattered. It is therefore proposed to hold under the auspices of the Marine Biological Association of India a symposium on SCOMBROID FISHES from 12th to 15th January 1962.

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* * * * *

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VOL. II December 1960 No. 2

STUDIES ON INDIAN COPEPODS 2. AN ACCOUNT OF THE MORPHOLOGY AND LIFE HISTORY OF A HARPACTICOID COPEPOD, *TISBINTRA JONESI*, SP. NOV. FROM THE GULF OF MANNAR*

By A. N. P. UMMERKUTTY
Central Marine Fisheries Research Station, Mandapam Camp

PART I. DESCRIPTION OF THE SPECIES

SEWELL (1940) erected the genus *Tisbintra* to receive a single female copepod which he obtained during the John Murray Expedition in a surface tow-netting in the Nankauri Harbour, Nicobar Islands. To my knowledge no other species has so far been added to this genus and the genotype itself, *T. nankaurica* Sewell, has never again been recorded (Dr. Sewell has confirmed this in a personal communication). The discovery of a new representative of this genus with many morphological deviations is, therefore, of interest ; specially so, because of the light it throws on the systematic position of the genus. Below is given an account of the morphology and life history of a new copepod obtained from the Gulf of Mannar and identified as a species of *Tisbintra* Sewell.

The occurrence of this species was first observed by Dr. S. Jones and it was at his instance that a detailed examination was undertaken. I have, therefore, much pleasure in naming the species *T. jonesi*.

Gooding (1957) has called attention to the fact that several terms have from time to time been used to differentiate the regions of the copepod body. Sars (1901) was the first to introduce some order by suggesting the terms cephalosome, metasome and urosome, the first two together to denote the usually broader anterior region and the last to denote the narrower posterior region respectively, irrespective of the morphological origin. Wilson (1932) adopted the nomenclature of Sars but interpreted that part of the body in front of the movable articulation as the metasome

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(which actually is the combined cephalosome and metasome of Sars) and the part behind the articulation as the urosome ; but in the text he has used other terms very frequently. I have adopted the terminology suggested by Gooding (*loc. cit.*) which appears to have definite advantages over the earlier ones. But the term abdomen may be added to denote the post-genital segments. In an earlier paper (Ummerkutty, 1960) I used the terms basipod, exopod and endopod to indicate the basal segment-complex and the external and internal rami respectively. The first term is probably not appropriate for the basal segment-complex actually comprises what are usually termed as coxopodite and basipodite; the term ' protopod ' would be a correct one. In this paper the ' endopod ', the ' exopod ' and the protopod have been employed not only to describe the parts of the swimming legs but also for those of the cephalosomal appendages of the adult animals. The terms ' protopodite, ' ' endopodite ' and ' exopodite ' have been used only in the case of copepodites. In describing the ornamentation of the swimming legs I have followed Sewell (1949) in differentiating spines by Roman and setae by Arabic numerals.

The holotype, allotype and paratypes have been deposited in the Reference Collection Museum of the Central Marine Fisheries Research Station. All the diagrams are drawn with the aid of a *camera lucida.*

Tisbintra Jonesi sp. nov.

Occurrence. The species was first observed in the marine aquarium tanks of the Central Marine Fisheries Research Station. The animal was found to creep on the glass walls and on the decaying vegetable matter on the bottom, probably feeding on them. It is of interest to note that this was one of the few copepods found to establish in good numbers in the aquaria to which it gains access through the pumping system.

In nature they were captured in the coastal plankton when the sea was in a disturbed condition. It appears that it is a bottom dweller and is brought upto the surface by water movements.

Female

The colour. Body is transparent, tinged with faint yellow ; dark shades are present in the mid-dorsal region of the metasomal segments. In mature specimens the ovary and its branches are seen as dark bands. So also is the gut when it is filled with food. *The body* is depressed, the anterior and posterior regions being clearly demarcated. The prosome is rather elongate-ovate, a little less than twice as long as wide and is vaulted dorsally. Cephalosome is fused with the first pedigerous segment and is almost as long as all the metasomal segments combined. The epimeral plates of the second and third prosomal segments are well-developed, being produced laterally and posteriorly and are rounded at the edge ; that of the last segment is very small without lateral expansion. Urosome is moderately slender ; the genital segment is as long as the next three segments combined and is divided dorsally along the middle (Fig. I, 1). On the ventral side the division is incomplete and there is a transverse genital aperture which is guarded by a long slender spine on each side (Fig. I, 2). The longest specimen measures 1.1 mm. and the proportional lengths of the prosome and the urosome are 59 : 41. The second innermost furcal seta is the longest and is distinctly longer than the urosome.

Antennule (Fig. I, 3) is short, hardly exceeding the length of cephalosome and consists of 8 segments having the following proportions :

1	2	3	4	5	6	7	8
9.5	25.0	21.0	22.5	4.0	5.0	4.5	8.5=100

The antennule carries a large number of rather short setae and the presence of a crescent-shaped knob, just beyond the mid-length of the third segment bearing 4 radiating setae, is a characteristic feature. The aesthetask on the 4th segment is well-developed and extends far beyond the tip of the antennule. The latter is divided into proximal wider and distal narrower parts, each being composed of 4 segments ; the distal four segments are much smaller and their combined length is just a little more than 1/4th of the proximal wider part. *Antenna* (Fig. I, 4) : The endopod consists of 3 segments, the terminal segment being the longest. The first segment carries a very small bristle on the outerside, at one-third of the length of the segment and a long seta at its distal inner margin. The second segment is devoid of any seta. The third segment has two stout setae on the anterior margin a little beyond the mid-length. At the apex it has one spine and five setae, 3 of which have a characteristic curve. The exopod is composed of two segments and is attached to the side of the basal endopod segment ; the proximal segment is shorter bearing one seta ; the distal one bears two setae basally and three terminally one of which is very small. *Labrum* (Fig. I, 5) : This is rather prominent tapering distally ; terminal edge is denticulate, coarse in the middle and finer at the sides. In addition, two fine hairs are present on either side of the denticulated area. *Mandible* (Fig. I, 6) : This consists of a biramous palp and a slender biting ramus. The latter is provided with several teeth at the apex and has a truncate projection on its postero-lateral margin. The rami of the palp are uniarticulate and slender and are borne on a uniarticulate protopod. The two rami represent the exopod and the endopod. *Maxillule* (Fig. I, 7) : A palp is present but an epipodal lobe is entirely lacking. The body of the maxillule is provided with a tuft of setae at its apex, a strong solitary seta sub-terminally on the distal outer margin and 2 short setae on the ventral side ; the latter actually terminate two elevated lines which converge towards the apex. The palp carries a number of setae which are arranged linearly along its inner margin from the mid-length to the apex. *Maxilla* (Fig. I, 8) : This is two-segmented but the segmentation is not easily discernible ; there is no lateral lobe on the basal segment ; the distal segment bears at its apex a long stout claw which is serrate at the distal inner edge ; a process, spatulate and fringed, is present on the inner margin of the claw just beyond its mid-length ; a group of 4 radiating bristles and an accessory spine are present near the base of the claw. *Maxilliped* (Fig. I, 9) : In the maxilliped, the third segment is not separated from the second ; the terminal claw is very slender and distinctly longer than the second and third segments combined ; the accessory spine, as in the maxilla, is close to the base of the claw ; the basal segment is sparsely provided with hairs ; in addition, it bears a small projection at its proximal outer margin which is provided with a tuft of hairs.

First leg (Fig. I, 10) : The exopod consists of three stout segments and the endopod of two much elongated segments, both closely resembling those of *T. nankaurica* Sewell ; but the arrangements of spine on the exopod is different from that of the latter species. The marginal spine on the first exopod segment is long with a wavy appearance whereas that on the second exopod segment is short and stout, a condition generally found in species of *Tisbe* and in contrast to that of *T. nankaurica*. Exopod II is of about the same length as exopod I and bears an inner seta and an outer spine ; exopod III is quadrate in form and bears two slender spines

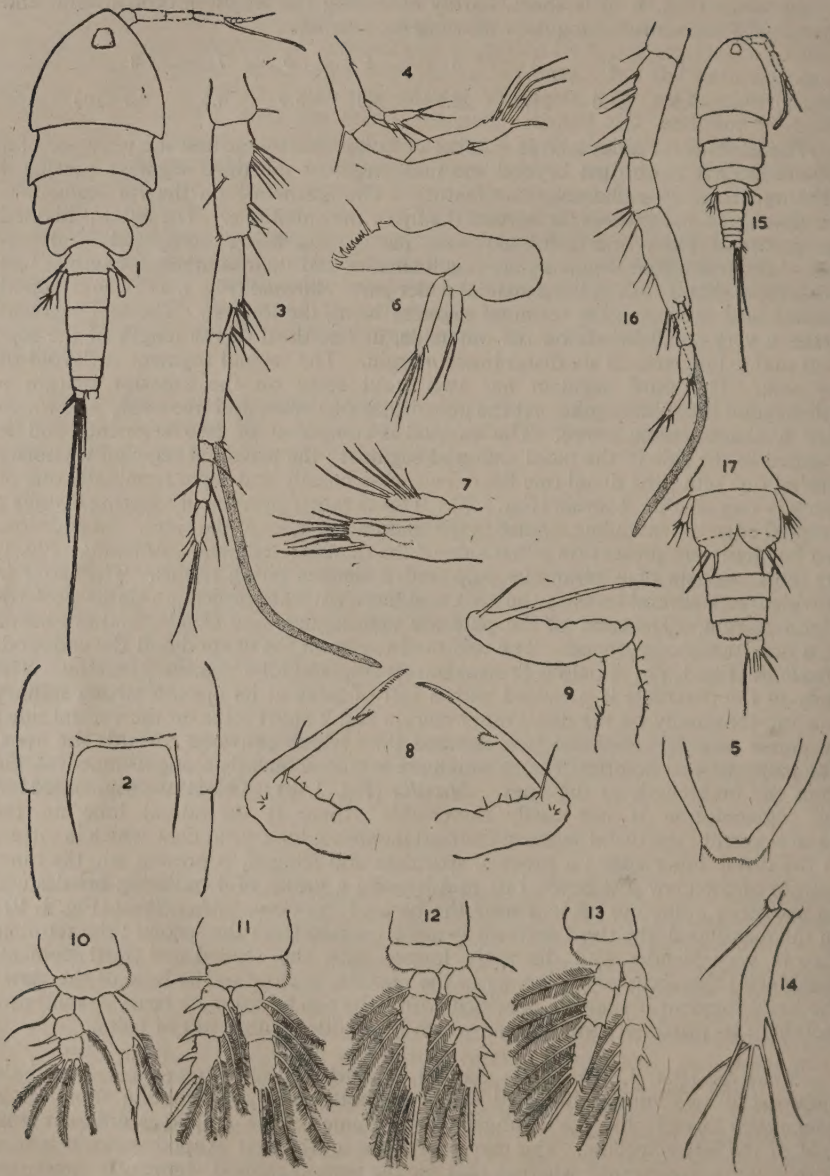

FIG. I

1. Female, adult, dorsal view.
2. ,, genital segment ventral view.
3. ,, antennule.
4. ,, antenna.
5. ,, labrum.
6. ,, mandible.
7. ,, maxillule.
8. Female, maxillae.
9. ,, maxilliped.
10-14. First to fifth legs.
15. Male, adult, dorsal view.
16. ,, urosome ventral view.
17. ,, antennule.

on its outer margin and four plumose setae at the apex. The endopod is considerably longer than the exopod and consists of only two segments of approximately equal length; the proximal segment is moderately stout, is equal in length to the three exopod segments combined and bears a single inner seta at about the junction of the middle and distal thirds ; the distal segment is slender and bears a spine at about its mid-length and two spines at its apex one of which is stronger and longer than the other. Both segments of endopod bear small hairs on their inner margins. Second, third and fourth legs (Fig. I, 11, 12 & 13) are all with 3-segmented rami and are more or less similar in appearance. However, in the second leg the proximal spine on the third segment of the exopod is markedly reduced in size. The number of setae and spines borne by different segments of the endopods and exopods are given below (Si, St and Se represent the inner, the terminal and the outer margins of the segments ; and P_2-P_4 represent the second to third swimming legs).

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P2	0	0	0	1	1	0	2	0	4	I	0	1	I	1	I	3	I	III
P3	0	0	0	1	1	0	2	0	5	I	0	1	I	1	I	4	I	III
P4	0	0	0	0	1	0	2	0	4	I	0	1	I	1	I	4	I	III

Fifth leg (Fig. I, 14) : In the fifth leg the basal segment is produced externally in a small conical process that bears a long and a short seta and a few hairs at its tip ; there is no inner expansion ; the distal segment is cylindrical, narrower at the base than at the apex and is 6 times as long as broad ; it bears one seta subterminally on its distal inner margin and 4 setae at the apex, one of which is smaller than the other three setae which are rather subequal.

MALE

The male (Fig. I, 15) resembles the female in general form but measures only 0.64 mm. The proportionate lengths of the prosome and urosome are 66.6 : 33.4. The differences between the two sexes consist of the geniculate antennule, the presence of vestigeal sixth pair of legs and the six-segmented nature of the urosome of the male, besides the smaller size of the latter. *Antennule* (Fig. I, 17) : This forms a grasping organ and is strongly built and consists of only 7 segments having the following proportions.

1	2	3	4	5	6	7
9.5	25.0	11.5	25.5	9.0	9.5	10.0 = 100

The aesthetask is borne by the fourth segment as in the female. The antennules are not provided with as many setae as are present in the case of female.

The genital armature or sixth pair of legs (Fig. I, 16) is a broad bi-lobed flap covering the entire ventral side of the genital segment and part of the succeeding segment. It bears 3 spines on either side ; the innermost is stout and backwardly directed ; the outer ones are rather slender and posterolateral.

The urosome is 6-segmented consisting of the fifth leg-bearing segment, the genital segment and 4 abdominal segments. The first segment is of about the same proportionate dimensions as in the female. The genital segment and the first abdominal segment are subequal and are the largest segments of the urosome. The last three abdominal segments diminish in size to the posterior side.

T. jonesi differs from *T. nankaurica* in a number of features and they are listed below :—

T. nankaurica Sewell	*T. jonesi* sp. nov.
Size of the female 1.23 mm. and the proportional lengths of prosome and urosome=62 : 38	Size of the female 1.1 mm. and the proportional lengths of prosome and urosome =59 : 41.
Rostrum distinct.	Rostrum indistinct.
Second inner furcal seta is as long as the urosome.	Much longer than the urosome.
Genital segment in female divided laterally.	Divided laterally and dorsally.
The genital aperture situated very near to the proximal end of the segment and the spines guarding the aperture hardly reaching its mid-length.	The genital aperture situated at about $\frac{1}{4}$ the length of the genital segment away from its proximal end and the spines guarding the aperture reaching well into its $\frac{3}{4}$ length.
The setation on the antennule very sparse.	Rather profuse. A characteristic crescent-shaped knob bearing 4 radiating setae present on the third segment.
The apical setae of the endopod of second antenna all straight.	Three of the setae have a characteristic outward bend at their 2/3 lengths.
Maxillule and its palp each tipped with a tuft of stout spine-like setae.	In addition to the terminal tuft of setae, the maxillule also bears 3 spines, one on the distal outer margin and 2 on the ventral side. The maxillular palp bears a number of setae on its inner margin arranged linearly from about the mid-length to the apex.
Maxilla is comparatively simple in structure with only a single stout terminal claw, having no serration.	An accessory spine present near the base of the terminal claw which bears on its inner margin near the centre, a spatulate and fringed process. The distal end of the claw is serrate.
Maxilliped not described or sketched by Sewell.	Maxilliped apparently with no division between the second and third segments. An accessory spine and a terminal claw present.
The marginal spine on the first exopod segment of the first leg is of moderate length whereas that on the second segment is considerably longer.	The marginal spine on the first exopod segment of the first leg is considerably longer than that on the second segment.
Exopod III of first leg bears 3 delicate setae-like spines on the outer margin and 4 plumose setae on the distal margin.	Exopod III of first leg bears 2 delicate seta-like spines on the outer margin 4 plumose setae on the distal margin.
Second segment of first endopod bears a single straight spine distally.	Second segment of first endopod bears 2 spines one of which is shorter than the other.
Fifth leg long and slender with one inner and three terminal setae.	Fifth leg long and slender with one inner and four apical setae.

Notes on the Genus—The absence of male specimens of *T. nankaurica* and the fact that the genus has been based on a single species have naturally placed limitations on the scope of its definition as provided by Sewell. When new allied forms, not sharing all the features of the genus are discovered, the original definition would

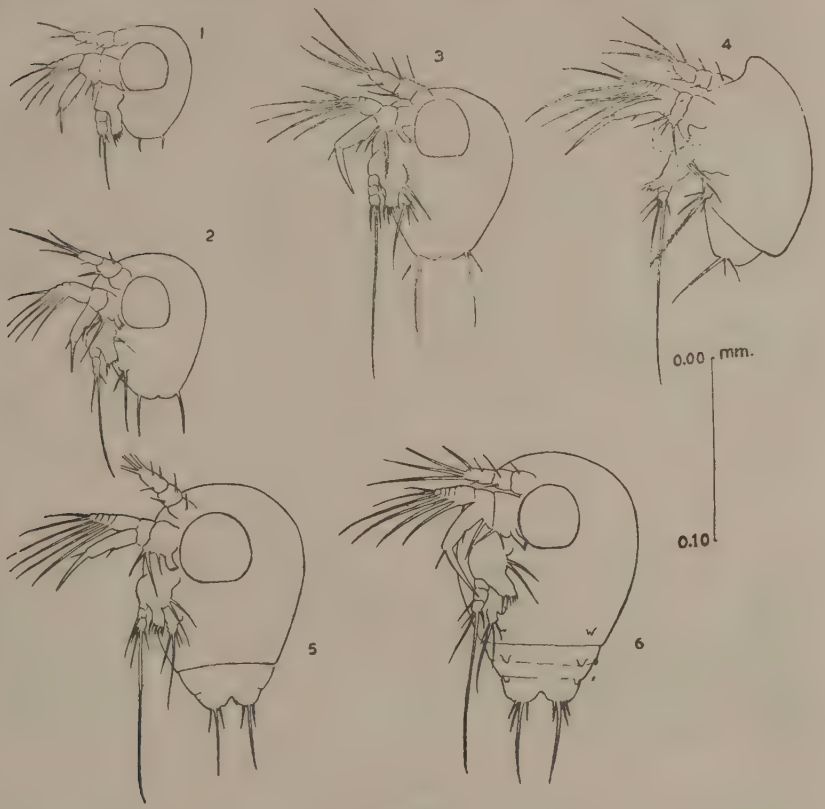

FIG. II

1-6. Naupliar stages first to sixth. Fourth stage lateral view ; all the others ventral view.

require either modification or expansion. Alternately the new forms could be kept as a subgroup in the older genus. In the present case it appears that it is not in the fitness of things to treat *T. nankaurica* and *T. jonesi* as anything more than two species of the same genus for they both possess many common features. However, this would necessitate some alteration in the definition of the genus *Tisbintra*. The presence of a rounded rostral projection on the cephalosome, for instance, is considered as a generic character by Sewell. In the present species the rostrum is absent although it is undoubtedly a representative of the genus. Again, in *T. nankaurica* the genital segment shows transverse division only laterally and this is described as a generic character by Sewell ; in *T. jonesi* the division extends to the dorsal side as well. Conversely, the highly reduced proximal spine on the terminal segment of

the exopod of the second leg is described as a specific feature by Sewell. It appears that this character may well be of generic importance for it is present in *T. jonesi* also. In view of these facts the genus *Tisbintra* Sewell is redefined here as follows :

Body depressed ; cephalosome fused with the first segment, forming the cephalothorax ; the epimeral plates of first and second metasomal segments are produced laterally and posteriorly and are rounded at the edge ; that of the third metasomal segment distinctly less wide. Urosome half as wide as the metasome ; the segment bearing the fifth leg greatly narrowed and is almost as wide as the following genital segment ; the latter in female long and divided and is provided with 2 long spines, one on either side of the genital aperture ; in male it is provided with a well developed genital armature ; Abdomen 3-segmented in female and 4-segmented in male. Caudal rami short with second inner seta much elongate ; antennule slender, 8-segmented in female, 7-segmented and geniculate in male ; endopod of antenna 3-segmented, exopod 2-segmented and much smaller ; the mandible possesses a biramous palp and a slender biting ramus provided with several teeth distally and with a truncate projection on its posterior margin ; maxillule without an epipodal lobe ; maxilla and maxxiliped both uncinate. Endopod of first legs 2-segmented and prehensile, exopod 3-segmented and natatory ; rami of second, third and fourth legs 3-segmented ; proximal spine on the third exopod segment of second leg markedly reduced in size ; fifth leg 2-segmented, basal segment without an inner expansion, distal segment narrow, and elongate. A single ovisac present.

Part II. Life History

Procedure. Live egg-carrying females were picked from aquarium tanks and fresh plankton and kept in filtered sea water contained in beakers of 100 cc. and 200 cc. capacities. In most cases it hardly took more than 24 hours for the larvae to hatch out, depending on the condition of maturity of the eggs. The hatching was cent percent successful and the larvae thus hatched developed through all the naupliar and copepodite stages to the adults, the whole process taking 7 to 9 days, in normal room teperature (28° C-31° C), varying according to the intensity of feeding. The animals were fed on a variety of marine food items such as powdered *Gracillaria crassa*,* ground dried clams and a variety of fresh chopped sea weeds. All these appeared to be quite acceptable to the copepod.

Stages were picked at regular frequent intervals and preserved for subsequent study. Live specimens of the various stages also were examined. Experiments were repeated and the nauplii and copepodites were studied from different series of culture to confirm the results. Samples containing all the different developmental stages were also taken from aquarium tanks for examination and comparison. However, no nauplius or copepodite (except a few fifth stages) were obtained from the plankton.

All drawings have been made from specimens reared in the laboratory. The instars are separated only by one moult as in other copepods that have been studied. There are six naupliar and six copepodite stages, the last of which is the adult. They are described below in detail. All the diagrams were made with the aid of a camera lucida.

* Kindly supplied by Dr. (Mrs.) F. Thivy.

Naupliar Stages. There are six naupliar stages the last of which moults into the first copepodite. Like most of the harpacticoids the naupliar stages are bottom-living and come up to the surface waters only when they are disturbed. They are highly depressed, sub-circular in shape and transparent. They swim about gracefully and are capable of performing quick creeping movements along the glass walls of the culture jars and the pieces of algae that are introduced as food items.

Nauplius I. (Fig. II, 1)

The first nauplius varies in length from 0.58-0.62 mm. and lasts for about 12 hours at 28° C-31° C. It has 3 pairs of appendages, the antennule, the antenna and the mandible. The antennule is 3-segmented with the terminal segment bearing 3 setae, two at the apex and one at the mid-length, and the middle segment carrying 1 seta. In the atenna the endopodite is stoutly built and 1-segmented, terminating in a stout claw more than half as long as the ramus itself. It also carries 2 spines, one near the claw and the other at the mid-length. The exopodite is 4-jointed, first three of them carrying 1 seta each and the apical one 2 setae. The endopodite and the exopodite are borne on a bimerous protopodite. The protopodite I of antenna is provided with a rudimentary masticatory blade ; Protopodite II bears 2 spines. Mandible consists of an exopodite of only two joints of equal length and an endopodite of one segment which is as long as the combined length of the exopodite segments. Exopodite II bears 3 setae, one of which is very long. Endopodite bears 2 fine setae and 3 spines. The caudal armature consists of 2 rather flaccid setae.

Nauplius II. (Fig. II, 2)

The second nauplius varies in length from 0.80-0.90 mm. and lives for about 16-20 hrs. at normal room temperature. The structural advances over the first stage are as follows : Antennule is 3-segmented ; 2 setae are present on the second segment and an additional apical seta on the third segment ; first segment is still without any seta. The masticatory blade of the antenna is well defined and is denticulate. Of the two setae present on the second protopodite, the inner one becomes longer and setiferous while the outer one is more spine-like. Mandible : The protopodite (which is still unsegmented) bears 2 setae, one of these being twice as long as the other. Maxillule appears as two strong setae, borne on a bud, one on either side just behind the mandible. Caudal armature, again, consists of 2 setae which are comparatively longer and stouter than those of the first stage. The posterior margin of the body of the nauplius gives a cleaved appearance.

Nauplius III. (Fig. II, 3)

The length varies from 0.10-0.105 mm. and the duration of life is the same as in the second stage at 28°C-31°C. The third stage shows the following morphological advances over the second stage. Antennule : First segment now carries 1 seta and the terminal segment is with one more seta at mid-length. Mandible : Fine bristles appear in the basal inner margin, of the protopodite, just before the two setae and the long seta of the terminal exopodite segment is longer than the entire body. Maxillule : A small additional seta appears on the inner side of the large seta and a protopodite is present. Caudal armature now consists of two setae on either side, the inner one being much longer than the outer.

Nauplius IV. (Fig. II, 4)

The length varies from 0.12-0.125 mm. and lasts for about 14 to 16 hours at normal room temperature. The number of setae present on the segments of antennule remains the same except that one seta is added in the terminal segment, bringing the total number to six. Antenna : The masticatory blade is quite long and a seta is present near its base. A third seta is added to the two setae on the second protopodite segment. The exopodite becomes 5-segmented, the first 4 segments bearing one seta each and the terminal segment 2 setae. Mandible : Terminal exopodite segment bears 4 apical and one subapical seta. The masticatory palp is stouter than in the previous stage. Maxillule is quite well-developed with 4 setae, one of which is very stout and long bearing hairs all along its length. Each caudal ramus carries 2 small setae in addition to the long seta.

Nauplius V. (Fig. II, 5)

The fifth stage varies in length from 0.135-0.140 mm. and live for 14 to 18 hours at normal room temperature before moulting into the next stage. This stage is very similar to the fourth stage, but the segmentation of the posterior region becomes much more distinct. The oral appendages show little change except the maxillule which now shows signs of segmentation. Each caudal ramus carries 3 setae.

Nauplius VI. (Fig. II, 6)

This stage varies in length from 0.14-0.15 mm. and lives for about 20 to 24 hours. The sixth nauplius moults into the first copepodite and is far advanced in structure than the fifth stage. The rudiment of maxillae and first and second pairs of legs are present as buds. But none of these bears any seta. The other appendages are very similar to those of the fifth stage. There are four setae on each caudal ramus and they are all longer and stouter than those of the previous stages. The distinguishing features of the sixth nauplius are the clearly segmented hind part of the body and the presence of the rudiments of the first and second swimming legs.

Copepodite Stages. There are five copepodites, the last of which moults into the adults. Like the nauplii the instars are separated by only one moult. The copepodites are active creatures most of them creeping about on the algal pieces in the culture dishes and making quick movements at slight disturbances. The segmentation of the prosome and the urosome as well as that of the swimming feet follow the general pattern of the harpacticoid development.

Copepodite I. (Fig. III, 1)

The first copepodite is a miniature adult, but with only 5 segments, 3 prosomal and 2 urosomal and the distinction in width between the two regions is considerably small. The caudal rami is wider than long and stuffy. The furcal setae are all well-developed and resemble those of the adult.

All the mouth parts have made their appearances and resemble the adult structures in their basic pattern. The details of the differences from the latter are

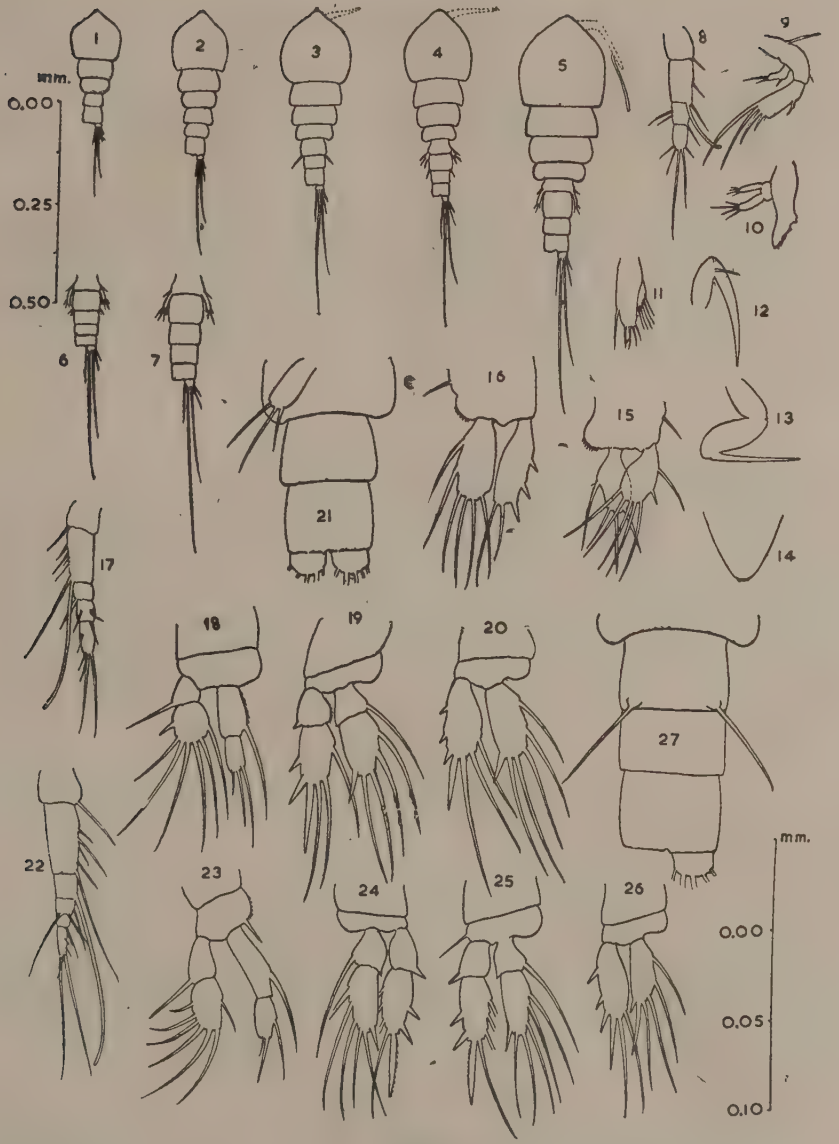

FIG. III

1-3. Copepodite first to third.
4. Copepodite IV male.
5. Copepodite IV female.
6. Urosome of Copepodite V male.
7. ,, ,, V female.
8. First Cop. antennule.
9. ,, antenna.
10. ,, mandible.
11. ,, maxillule.
12. ,, maxilla.
13. ,, maxilliped.
14. ,, labrum.
15-16. first and second swimming legs.
17. Second Cop. antennule.
18-20. ,, first to third swimming legs.
21. ,, urosome with last prosomal segment carrying the fifth eg.
22. Third Cop. antennule.
23-26. ,, first to fourth legs.
27. ,, Urosome with vestigeal fifth leg, ventral view.

(Diagrams 1 to 7 of Fig. III are drawn according to Scale 1 and 8 to 27 according to Scale 2).

noted below : Antennule (Fig. III, 8) : This is only four segmented ; the third segment bears a fine aesthetask. Antenna (Fig. III, 9) : The division of exopodite into 2 segments is not discernible. In the endopodite there are only 4 apical setae and a small bristle. Maxilla (Fig. III, 12) : The spatulate process of the apical claw has not yet appeared ; the terminal edge of the claw not serrated. Maxilliped (Fig. III, 13) : No accessory spine is present ; the tuft of hairs on the proximal segment is absent.

There are only two pairs of swimming legs and vestige of the third (Fig. III, 15 & 16). The rami of both the first and second legs are 1-segmented. The vestigeal third leg is peg-like, bearing 3 setae. The exopodite of first leg anticipates the adult structure : the proximal spine is already much longer than the second spine, a character which the present species possesses, in contrast to the only other known species of the genus, *T. nankaurica*. The division of the protopodite is not clear. The average length of this stage is 0.208 mm. It lives for about 18 hours under normal room temperature (28°C-31°C).

Copepodite II. (Fig. III, 2)

The number of segments is increased to six, 4 prosomal and 2 urosomal. The general appearance is similar to that of the first stage. Antennule (Fig. III, 17) is 5-segmented, the second one bearing the aesthetask. All other mouth parts show adult structures except the maxilla which still has not developed the spatulate process on the terminal claw. There are three pairs of swimming legs and a vestige of the fourth (Fig. III, 18, 19, 20 & 21). The rami of the first two legs are 2-segmented and those of the third leg 1-segmented ; the protopodites of all the three pairs of legs are clearly 2-segmented. The vestigeal fourth leg is only a small process with three terminal setae. The average length of this stage is 0.375 and the duration of life about 20 hours.

Copepodite III. (Fig. III, 3)

There are 4 segments in the prosome while a third segment is added to the urosome. The distinction in width between the two divisions is more pronounced than in the preceding stages. Antennule (Fig. III, 22) is 6-segmented the third segment bearing the aeshetask. The other cephalosomal appendages are very similar to those of the adult. There are 4 pairs of biramous legs and a vestige of the fifth (Fig. III, 23, 24, 25, 26 & 27). The rami of the first three pairs are 2-segmented and those of the fourth only 1-segmented. The protopodite of all the four pairs of legs are clearly segmented. The protopodite II of first legs has not yet developed the seta on its outer margin. The fifth vestigeal segment is borne by the first urosomal segment and is each represented by only a single seta with a well defined base. The average length is 0.460 mm. This stage lasts for about 20 hours.

Copepodite IV. (Fig. III, 4 & 5)

Prosomal and urosomal segments are now equal in number, each region being composed of four segments. The body has all the adult features, including the lateral expansion of the first and second metasomal segments and the dimorphism of the sexes. The male is much smaller than the female being only slightly longer than the third stage :

The size of the male=0.490 mm.

The size of the female=0.577 mm.

The sexes are easily distinguished by the presence on the second urosomal (genital) segment of the male of a spine representing the vestige of the sixth pair of legs (the so-called genital armature, Fig. IV, 1).

The antennule is 7-segmented in both sexes (Fig. IV, 2). The first four pairs of swimming legs are biramous, each ramus being composed of 2 segments (Fig. IV, 3, 4, 5 & 6). The fifth pair of legs (Fig. IV, 1) consists of a short peg-like structure with three apical and one basal setae. In the male the sixth pair of legs is each represented by a single seta projecting postero-laterally from the second urosomal (genital) segment. The fourth stage lives for about the same period as the third stage.

Copepodite V. (Fig. III, 6 & 7)

This stage has nine segments, 4 prosomal and 5 urosomal in both sexes. In the female the genital segment is not yet divided but is distinctly longer than the other segments of urosome. The two spines on either side of the genital aperture are present but are shorter than those of the adult. Length of the female is 0.832 mm. and that of male 0.535. Antennule : This is stumpy and 7-segmented in male (Fig. IV, 8) and normal and 8-segmented in female (Fig. IV, 7). In the latter all the adult features, including the crescent-shaped knob on the third segment have been formed. But in the male although the proximal segments of the antennule are foreshortened it has not become completely geniculate. All the swimming legs are present (Fig. IV, 10, 11, 12 & 13). The first four pairs of legs are biramous, the rami being 3-segmented except the first endopod which is only 2-segmented. The setation of the various segments are similar to those of the adult except in the fifth leg (Fig. IV, 14) where there are only 3 apical and 1 sub-apical setae whereas in the adult the corresponding numbers are 4 and 1. The proximal spines of the third exopodite segment of the second leg is considerably reduced in size.

The Adults

The detailed description of the adult male and female are given in the earlier part of this paper.

Remarks. Johnson and Olson (1948) have given an account of the life history of *Tisbe furcata* which they reared through all the stages in the Laboratory. Few more marine harpacticoids have been subjected to large amount of investigations and much detail is known about their life histories and reproduction. (Nicholls, 1935 ; Fraser, 1936 ; Gurney, 1930 & 1932). However, the knowledge of the life histories of harpacticoid copepods from Indian waters is extremely meagre. Krishnaswamy (1950 and 1955) has given an account of the life histories of *Macrosetella gracilis* and *Leptostacus euryhalinus*. Rao (1958) described the developmental stages of *Euterpina acutifons*. Of these *Leptostacus euryhalinus* is a psammophilious copepod, the other two being planktonic in their habits.

Many previous investigators (Gurney, *loc. cit* ; Johnson, 1934 a & b ; 1935) have called attention to the striking similarity that exists between the nauplius larvae of marine copepods belonging to the same genus. Johnson (1935) cites the developmental stages of *Labidocera*, *Epilabidocera* and *Pontella* to show that this identity can be found even in the larvae of different but closely related genera and concludes

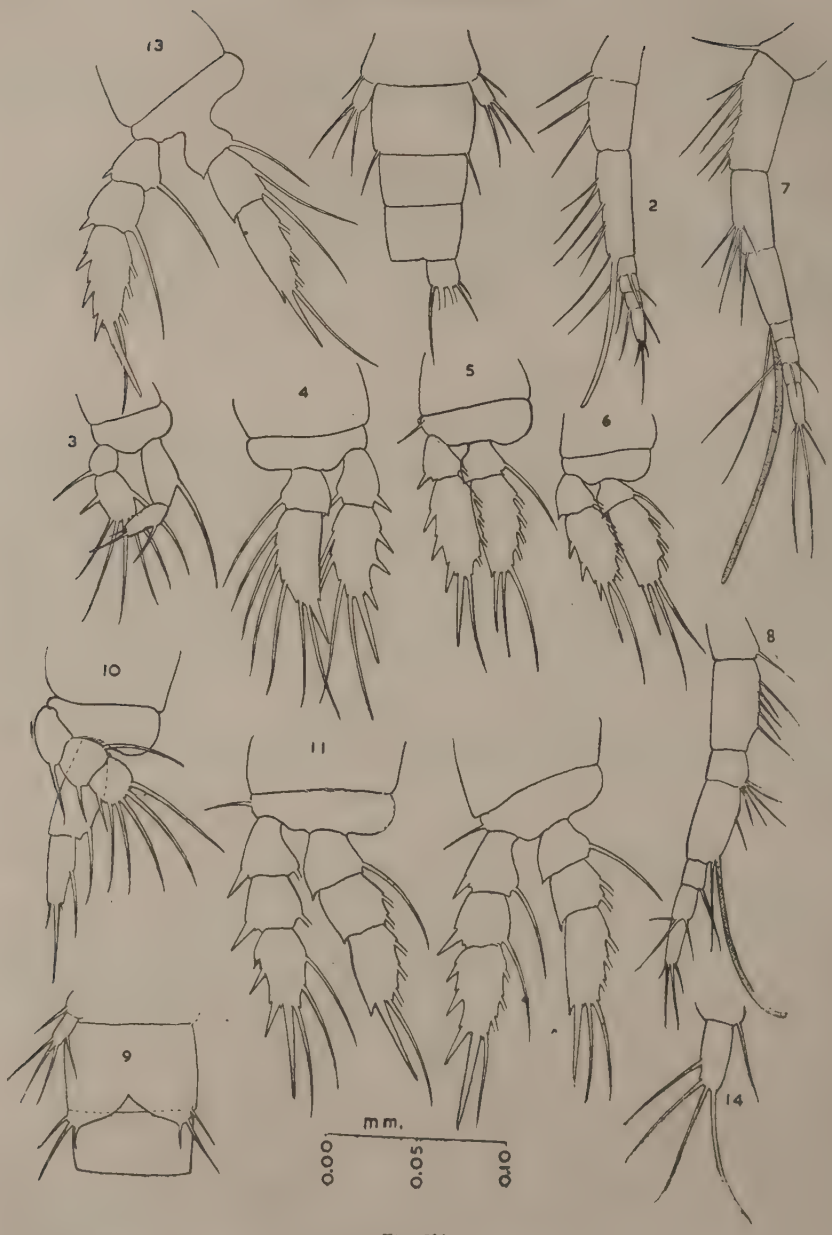

Fig. IV

1. Fourth Cop. male urosome with fifth leg, and vestigeal genital armature.
2. ,, antennule.
3. ,, first leg.
4-6. ,, female second to fourth legs.
7. Fifth Cop. female antennule.
8. Fifth Cop. male antennule.
9. ,, ,, first and second urosomal segments with fifth leg and genital armature.
10-14. ,, Female first to fifth legs.

that the larvae of allied genera conform each other in essential structural details. It is, therefore, not surprising to observe a very close similarity between the larvae of *Tisbintra* and *Tisbe*. In fact, that is what one should expect for these forms have not only close systematic kinship but they both occupy the same ecological niche, namely, the bottom inshore waters. A very close similarity exists between the naupliar stages of *Tisbintra jonesi* and *Tisbe furcata*. The real differences between these species, however, make their appearances from first copepodite onwards. Judging from the figures of Johnson and Olson (*loc. cit.*) it is clear even in the general appearance they are widely separated ; while the cephalothorax of *T. furcata* is almost as long as the combined length of all other four segments that of *T. jonesi* is just a little more than one-third the entire body length. The differences in the various copepodite stages of the two species, such as the reduced development of the proximal spine of the third segment of the second exopodite and 2-segmented nature of the endopodite of the first leg are traceable to the conditions of the adult.

Summary

(1) A new species of harpacticoid copepod *Tisbintra jonesi* is described in detail and a redefinition of the genus *Tisbintra* Sewell is rendered in the light of the information available regarding the male.

(2) The complete account of the life-cycle of this species is given. As in all other copepods that are studied there are six naupliar and six copepodite stages, the last of which is the adult.

(3) The striking similarities of the naupliar stages of *Tisbintra jonesi* with those of *Tisbe furcata* are briefly discussed.

Acknowledgements

I am grateful to Dr. S. Jones for his kind encouragement and guidance during the period of this work and to Dr. R. B. S. Sewell, Cambridge University, England, for the confirmation of the identification of the species. My thanks are also due to Dr. S. Krishnaswamy of the Madras University for going through the manuscript and offering valuable criticisms, and to Dr. S. Z. Qasim of Aligarh University and Dr. R. Raghu Prasad of this Station for many helpful discussions during the preparation of this paper.

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STUDIES ON INDIAN COPEPODS 3. *NEARCHINOTODELPHYS INDICUS*, A NEW GENUS AND SPECIES OF ARCHINOTODELPHYID COPEPOD FROM INDIAN SEAS*

By A. N. P. Ummerkutty

Central Marine Fisheries Research Station, Mandapam Camp

Hansen (1923) obtained from *Phallusia obliqua* (=*Ascidia obliqua*) an interesting species of copepod which he named *Cyclopina phallusiae*. Hansen himself was uncertain about the correct systematic position of this copepod, for a species of the genus *Cyclopina* was never known to live within the ascidian. Lang (1949) suggested the creation of a new family Archinotodelphyidae to receive *C. phallusiae* Hansen and a new species of copepod which he gathered from *Pyura georgiana* Mchlsn during the Swedish Antarctic Expedition. He placed the two species in two monotypic genera, *Archinotodelphys* to contain his own new species and *Pararchinotodelphys* to include *C. phallusiae*. This was a fitting arrangement in view of the important and far-fetching suggestions he had already made regarding the classification of copepods (Lang, 1948).

Illg (1955) discovered a second species of *Pararchinotodelphys* from the branchial cavities of *Styela partita* caught off Marthas Vineyard, Massachussetts. He provided an excellent discussion regarding the systematic position of all the three species and that of *Pseudocyclopina belgicae* Giesbrecht which was considered as congeneric with *Cyclopina phallusiae* by Lindberg (1952). In fact Lang's account of his new family and the two genera contained therein were very short and it was Illg who enlarged our understanding of this group.

Pararchinotodelphys phallusiae was obtained during the Danish Ingolf Expedition ; Lang obtained specimens of *Archinotodelphys typicus* from the Antarctic ; and Illg reported *P. gurneyi* from north-west Atlantic. The archinotodelphyid copepod described below is collected from the south-east coast of India and appears to require a new genus and species to accommodate it. The male is not known for any of the earlier species. In the present case a fair number of males and females have been obtained and efforts have been made to elucidate points of sexual dimorphism in this primitive family. In describing the various morphological characters I have mainly adopted the terminology suggested by Gooding (1957) with some alterations (Ummerkutty, 1960) There is no absolute agreement between the various investigators on the homology of the constituting parts of the cephalosomal appendages of the copepoda. The terms ' protopod ', ' endopod ' and ' exopod ' are used in this paper rather in a descriptive sense than to indicate any strict morphological origin. These terms have been employed not only to describe the constituting parts of the swimming legs but also for those of the cephalosomal appendages of the adult animals.

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Family : ARCHINOTODELPHYIDAE LANG (Lang, 1949, p. 3.)

Genus : *Nearchinotodelphys* nov.

The prosome consists of four segments : a cephalothorax formed by the fusion of the cephalosome and the first pedigerous segment and three free metasomal segments. The urosome consists in the female of the segment bearing the fifth legs, the genital segment and three abdominal segments ; in the male it consists of the fifth leg-bearing segment, the genital segment and four abdominal segments. The antennule is 15-segmented in the female and 14-segmented and geniculate in the male. The antenna is 4-segmented, the last segment bearing a strong claw accompanied by a number of setae. The mandibular palp has a 2-segmented endopod and a 4-segmented exopod. In the maxillule the endopod is 2-segmented while the exopod is only 1-segmented. The maxilliped is 3-segmented. The natatory legs have both rami 3-segmented. The fifth legs are 2-segmented ; 4 setae are borne on the terminal segment and 1 on the basal segment.

Genotype : *Nearchinotodelphys indicus* sp. nov.

Nearchinotodelphys indicus sp. nov.

Material examined—The material of the present study was obtained from the mantle cavity of a boring bivalved molluscan, *Lithophaga strimineus**. The specimens were first noticed by Dr. E. G. Silas who kindly passed them over to me. There were 11 females and 10 males. A few of them were slightly damaged but the majority of them were in good condition so as to permit a thorough examination. It is interesting to note that although the two sexes were present more or less in equal numbers, no egg-carrying female or naupliar or copepodite stages were found. The type specimens, the holotype, the allotype and the paratypes are deposited in the Reference Collection Museum of the Central Marine Fisheries Research Station, Mandapam Camp and bear the registered Nos. J 511/2, J 512/2 and J 513/2 respectively.

FEMALE

In general appearance the female (Fig. I, 1) resembles the three other known species except that in the present case the cephalosome and the first pedigerous segment are fused to form a cephalothorax. The latter is the widest part of the body and is almost twice as wide as the last metasomal segment and three times wider than the widest part of urosome. There is a distinct cap-like rostrum, narrower at the base. There are only 3 metasomal segments, diminishing in width posteriorly. The urosome consists of 5 segments : the fifth leg-bearing segment, the genital segment and 3 abdominal segments, the last of which bears a pair of caudal rami. The genital segment is the longest and shows signs of division laterally. The three abdominal segments are more or less of equal dimensions and distinctly smaller than the genital segment. The fifth leg-bearing is the widest of all urosomal segments ; the posterior half of this sigment is narrower than its anterior half which carries the fifth legs ; in preserved specimens a part of this anterior half is covered over by the last prosomal segment.

* Kindly identified by Mr. K. V. Rao.

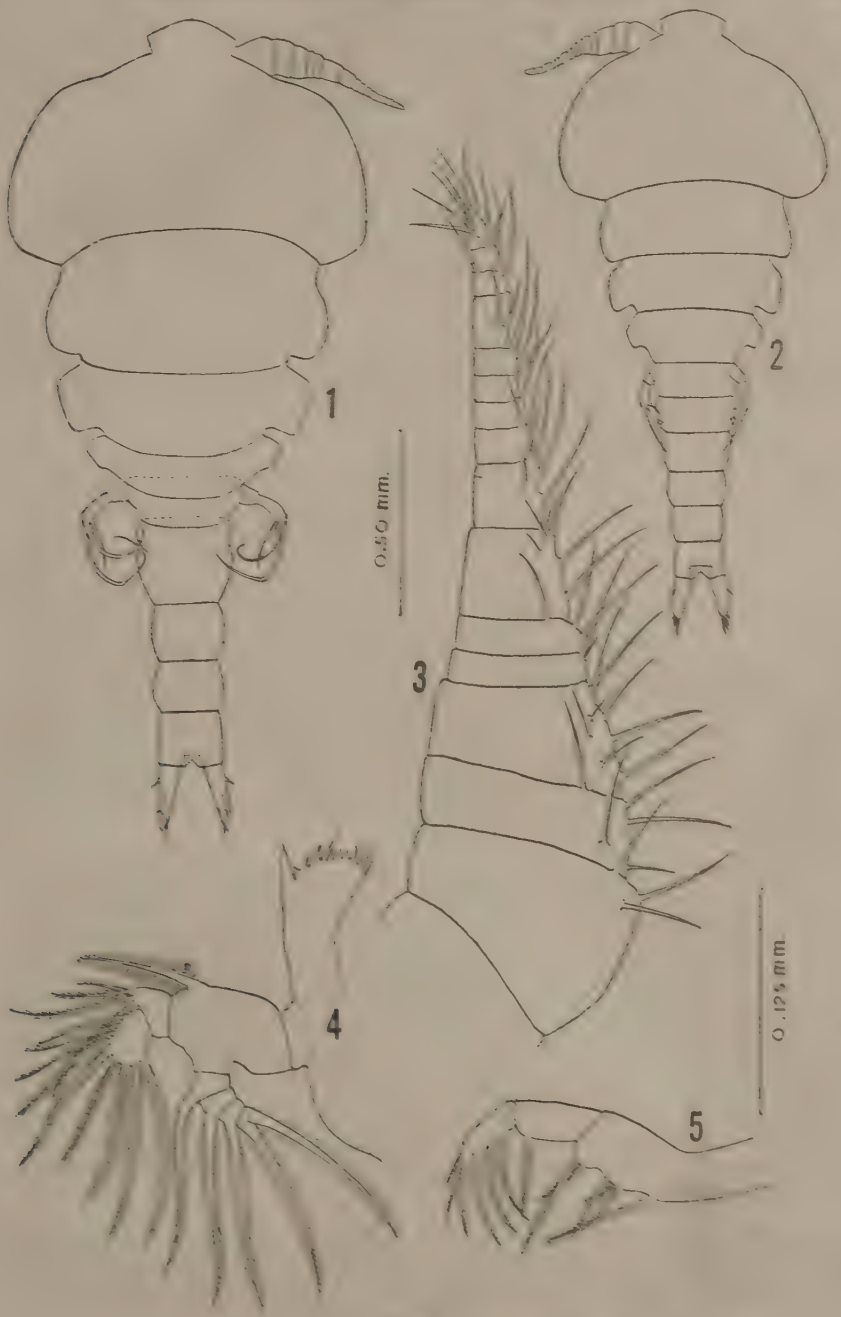

FIG. I.

1. Female, adult, dorsal view.
2. Male, adult, dorsal view.
3. Female, adult, antennule.
4. ,, ,, mandible.
5. ,, ,, maxilliped.

The caudal ramus calls for some comments. It is very different from those described for all the three known species. In the earlier species it is more or less cylindrical and at least one-half longer than the last abdominal segment and bears 4 fairly long apical setae, besides one (in *Archinotodelphys typicus* and *Pararchinotodelphys phallusiae*) or two (in *P. gurneyi*) short setae at some distance from the apex. In the present case, the caudal ramus is very short, just as long as the last abdominal segment and the setae are much shorter, the longest seta being only just a little more than half the length of the ramus itself. Further the setae are thicker at the base and taper posteriorly. In the earlier species the setae are long and slender and more or less of uniform thickness.

The proportionate lengths of the prosome and the urosome are 59 : 41.

Antennule (Fig. I, 3)—Antennule is very short, extended laterally in the natural position and hardly reaching the posterior margin of the cephalothorax, if held backwards. There are only 15 segments in the antennule and the proportions of the constituting segments are given below (All segments are measured along the middle line).

1	2	3	4	5	6	7	8	
17.3	8.0	11.7	4.4	4.8	11.2	8.7	4.8	
9	10	11	12	13	14	15		
3.5	3.5	3.5	7.0	3.0	3.0	5.6		=100

All the segments are provided with many setae except the 10th and 11th which are provided with one seta each. The proximal segments are much wider than the distal ones, the first segment being 8 times as wide as the 15th and the segments between them tapering gradually to the distal end. The 7th segment shows a slight sign of lateral division, but otherwise the segments are normal. No aesthetask or sensory filament is borne by any segment. The lengths of the different segments are uneven ; the first segment is the longest ; second, third, sixth and seventh are of moderate length with two short segments, the fourth and fifth segments, inserted between them. Eighth to fifteenth segments are short and subequal, excepting the 12th which is almost double the length.

Antenna (Fig. II, 7)—It is 4-segmented. In the first segment (basal) there are two juxtaposed setae of equal length, bearing hairs throughout their lengths. This condition is found only in *A. typicus* among the known species. The second segment is devoid of any seta. In the third segment there are two long setae at the outer distal margin and one short seta just before the mid-length. The last segment gives the appearance of being segmented ; whether the two halves represent actual segments or the division is only apparent is not clear ; probably the division is superficial for no constriction is observed in the region of the partition. Further, the proximal half is devoid of any seta. The last segment bears five setae and one claw on the apex and a very short seta on the ventral face at about one-third the proximal length of the segment. Of the apical setae, the distal two are very long and bent towards the claw ; the other three terminal setae are much shorter and rather straight. The claw is very large, broader at the base than at the apex and characteristically bent.

Mandible (Fig. I, 4)—The mandible is normal and is identical to that described for earlier species. It is a fairly massive structure having a masticatory blade and a biramous palp. The former is denticulated at the inner edge, the teeth becoming

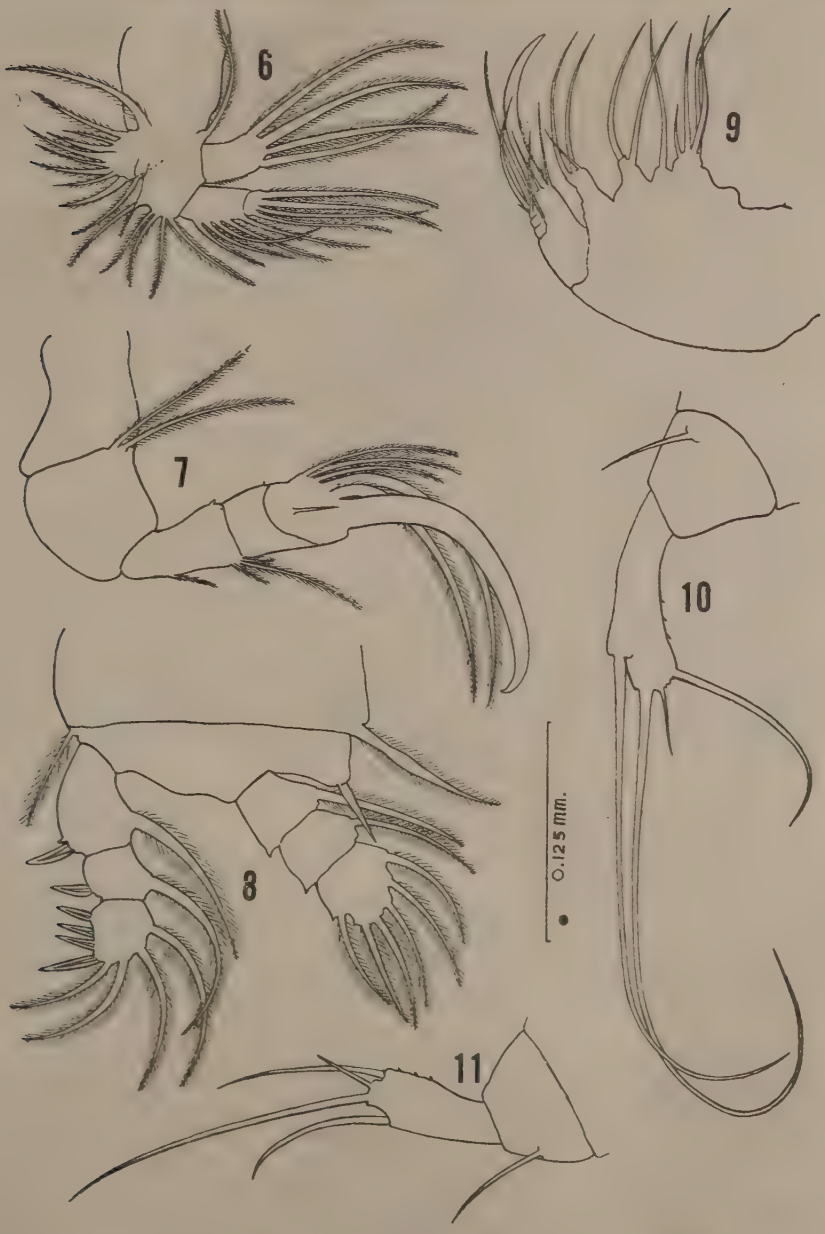

FIG. II.

6. Female, adult, maxillule.
7. ,, ,, ,, antenna.
8. ,, ,, ,, first swimming leg.
9. Female, adult, maxilla.
10. ,, ,, ,, fifth leg.
11. Male, adult, fifth leg.

more seta-like on one side and stout and strong on the other. The palp of the mandible consists of a protopod and two rami. The protopod is quite large and carries only a single seta, heavily setiferous and placed towards the distal margin. The endopod is 2-segmented, the basal segment carrying four setae. The distal segment bears nine setae which are arranged continuously along the inner, lateral and apical margins. The exopod is 4-segmented. Each of the first three segments bears one long seta, and the last two setae. All the setae are plumose.

Maxillule (Fig. II, 6)—A protopod, an exopod and an endopod can be distinguished in the maxillule. The protopod is a complicated structure and has been discussed in detail by Illg (*loc. cit.*). I am inclined to accept his interpretation and the following description is offered. The protopod is apparently bimerous. The basal protopod segment probably represents in the present case a fusion of the two endites. The proximal one is rather massive, bearing medially along its margin nine setae (some of which look more like spines) of varying proportions. The proximal-most seta is striking in that it is separated from the rest and is very long having a peculiar curve. The distal endite is very small and peg-like, bearing a solitary seta at the apex. The basal protopod segment also supports at the base of the exopod a protuberance carrying a seta. This is interpreted as representing a coalesced epipod.

The distal protopod segment is rather simple, but quite expanded. Its apparently outer lateral margin bears both the endopod and the exopod. On the opposite margin it bears two groups of setae ; the proximal group consists of one long and one short seta and the distal group of four setae of more or less equal length. The endopod is 2-segmented and the exopod is 1-segmented. The former bears five setae on the proximal segment, arranged all along its entire inner margin and four on the distal segment set apically. They are continuous and about equispaced and show gradual increase in length from the basal to the apical setae. The exopod is rather rectangular in shape, as large as the endopod but bearing only four setae, two of them apical and the other two subapical on either side. These setae are the longest of the maxillule and are plumose.

Maxilla (Fig. II, 9)—Here the first segment bears four groups of setae, each probably representing one endite. The first group bears four setae one of which is spiniform and shorter than the others. The second endite bears a long solitary seta. On the third endite there are two long apical setae and on the fourth there are three setae two of which are very long and the third spiniform and short. The second segment is produced medially as a heavy, tapering, slightly curved spine. At the base of this spine there is a pair of small setae, a feature not found in any other known species of the genus. The distal region is 3-segmented, each segment bearing a single longseta. It is a far smaller region, forming only a fragment of the whole appendage.

Maxilliped (Fig. I, 5)—This is 3-segmented. The basal segment is the longest, being longer than the other two segments combined. It carries three protuberances on the medial margin. The first is at about the mid-length of the segment and a single seta is borne on it. The second protuberance is equidistant from the first and the third and bears four setae of varying lengths. The third one is almost at the distal medial angle of the segment and is provided with two setae. The second segment is small, less than half the length of the basal and its ornamentation consists of a single seta borne subterminally on the medial margin. The last segment is the smallest both in length and width and bears six setae graduated in length from the base to the distal end.

FIG. III.

12. Female, adult, second leg.
13. „ „ fourth leg.
14. Male, adult, antennule.
15. „ „ maxilliped.
16. „ „ genital segment, ventral view.

Swimming legs (Fig. II, 8 and Fig. III, 12 & 13)—These appendages exhibit a similar pattern of organisation except in the setation of the various segments which is given below :

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P1	1	0	I	1	1	0	1	0	3	2	1	1	I	1	I	3	1	IV
P2	1	0	0	1	1	0	2	0	3	2	1	1	I	1	I	4	1	IV
P3	1	0	0	1	1	0	2	0	3	2	1	1	I	1	I	4	1	IV
P4	1	0	0	1	1	0	2	0	2	2	1	1	I	1	I	4	1	III

(Si, St and Se represent the internal, terminal and external margins of the constituting segments and P1—P4 represent the first to the fourth swimming legs. Spines are indicated by the Roman and setae by the Arabic numerals). The appendages are strongly built, biramous, each ramus being composed of three segments. In size the first legs are the smallest. It is borne by the cephalothorax, while the succeeding legs are each borne by a separate metasomal segment. In first legs the protopod I carries a single seta at the inner distal angle ; the protopod II a simple spine at the distal inner angle. The segments of the endopod are subequal in size and are more or less of equal length and width. In the exopod the first segment is the longest and second the shortest ; the former is narrower at the base. The second and third legs are alike in all respects. The first protopod is large and carries one seta at the distal innner angle. The second protopod segment carries a seta on its outer lateral margin. The segments of both rami resemble those of the first legs and differ only in ornamentation. The fourth leg although built on the same pattern gives a narrower appearance of the constituting segments of both the rami. The spines of the exopod segments are specially noticeable in that they are rather slender and straight and do not possess the partial curvature of the tip, a feature present in the spines of first, second and third exopods.

Fifth leg (Fig. II, 10)—The fifth leg is borne by the first urosomal segment and is bimerous. The proximal segment is stout, broader at the base than at the apex and bears a single seta at its one-third length. The narrower tip of the proximal segment merges into the base of the distal segment which is broader at its distal region. There are four setae on the distal segment, two apical and two subapical. Of the latter, one is borne on a protuberance in the distal outer side and is very long, about two times longer than the entire fifth leg ; the second seta is on the inner distal margin and is much shorter, only a little more than one-third length of the outer seta. The apex bears the shortest and the longest of the setae. The latter is one-fifth longer than the outer subapical seta and the former is extremely short, just a little more than half the length of the seta on the proximal segment of the fifth leg. All the setae bear minute hairs all along their lengths. Three bristles are found on the inner margin of the distal segment of the fifth leg.

Genital apertures (Fig. IV, 1)—The genital apertures are not described for any of the earlier species of this family. It is probably because of the limited number of specimens available to the investigators. The genital apertures in the present

species are very widely separated. They are set about one-third the proximal length of the genital segment and more or less ventro-laterally. The two apertures are connected by a narrow grove that run across the segment. The apertures are provided with minute spinules, probably guarding them.

Male

The male (Fig. I, 2) is much smaller than the female, but is very similar to it. The differences noticed in the structural details are in the antennule, the maxilliped, the fifth leg and in the urosome. In other aspects there is absolute similarity between the male and the female except for the smaller size of the former.

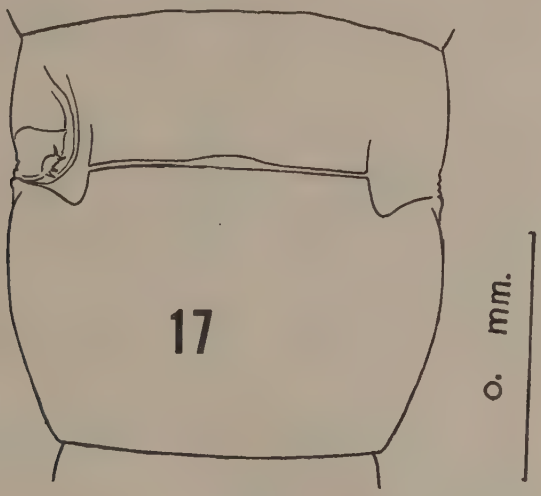

Fig. IV
17. Female, adult, genital segment, ventral view.

Antennule (Fig. III, 14)—The structure of the antennule may really be termed primitive for the geniculation found here is one of the simplest among the cyclopoids and the points of departure from the female antennule are not many. Both the left and the right antennules are built on the same pattern and each consists of only fourteen segments. The proportionate lengths of the constituting segments are as follows (All measured through the mid-line).

1	2	3	4	5	6	7	8	
20.2	7.4	10.6	5.3	5.3	5.8	4.3	3.7	
9	10	11	12	13	14			
7.4	4.3	4.3	8.0	6.9	6.5	..	..	= 100

It can clearly be seen that only the first five proximal segments have the same proportionate dimensions as those of the female antennule ; sixth and seventh segments which are fairly large in the female are here, only as large as the fourth and

fifth ; the eighth segment is smaller than any of the four earlier segments ; the ninth segment is quite large and is equivalent to the tenth and eleventh combined ; the last three segments are subequal and are geniculated. The twelfth segment bears a spine on its distal posterior margin and two fairly long setae on the same side. The thirteenth segment has a characteristic concavity on its anterior margin and bears a small straight spine at the depression and a long seta at the distal anterior angle. The last segment is profusely setated ; one seta is borne at one-third proximity, and the others at the distal region. There is a spine at half the length on the anterior margin. The length of the antennule in relation to the cephalothorax is similar to that in the female.

Maxilliped (Fig. III, 15)—This appendage shows variations from that of the female only in the proximal segment. While in the female it is longer than the combined lengths of the distal two segments, here it is distinctly smaller than that. It differs also in the setation : there is a solitary seta just beyond the one-third the proximal length and one long and two short spine-like setae at about two-third the length.

Fifth leg (Fig. II, 14)—The structural deviations of the male fifth legs are rather few. In the basal segment the position of the seta appears to have changed ; it is seen just beyond the middle length. In the distal segment the setae give an entirely different appearance. While the outer subapical seta in female is about two times the length of the entire fifth leg here it is only just a little longer than the distal segment of the latter ; the outer apical seta is again considerably reduced in length. Here also it remains the longest seta and is about twice as long as the outer subapical seta, but its length in proportion to that of the fifth leg itself is far less. Further both these setae lack their characteristic curved shape of the female. The reduction in length of the other two setae, namely, the inner apical and inner sub-apical, are only proportionate to that of the appendage itself. The three bristles found on the inner margin of the distal segment of the females are also present in the male.

Urosome—It is 6-segmented, consisting of the fifth leg-bearing segment, the genital segment and four abdominal segments. The segments are graduated, the first segment being the widest. The latter and the genital segment are more or less of equal length. On the ventral side of the genital segment is present what is generally called the genital armature (Fig. III, 16) or the vestigeal sixth pair of legs. The spines of this appendage are faintly seen from the dorsal side but the structural details can be studied only from the ventral side. It is peg-like, one on either half, occupying a major portion of the ventral surface of the segment and orientated more or less diagonally. There are three spines on the posterior tip of it ; the inner most is very small and the outer two are long and sub-equal. The four abdominal segments are barrel-like and approximately of equal length. The last one bears the caudal rami which show no speciality.

Discussion

Both Lang (1949) and Illg (1955) have stated that in the species they described the prosome consists of the cephalosome and four free leg-bearing segments and that the host animal is an ascidian. The present species differs from both these conditions on which so much stress has been made by Lang (*loc. cit.*) when he created the new family Archinotodelphyidae and the two genera contained therein. In accordance with *Cyclopinella* the first leg-bearing segment is free in *Archinotodel-*

phys and *Pararchinotodelphys*. But they differ from each other in the number of segments of the urosome. While *Archinotodelphys* has a urosome of six segments *Pararchinotodelphys* has only five segments in the urosome, a feature which relates the former genus to Notodelphyidae.

In the present example the cephalosome and the first pedigerous segment are fused ; this is a character which directly relates it to many Cyclopinidiformes and Notodelphyidiformes and which is customarily held significant at a generic level (*vide* Sars, 1918, p. 16). The occurrence of the species in a molluscan host instead of the ascidian in unison with its relatives is another important fact in the evolution of the host-parasite relationship in this group of animals. *Nearchinotodelphys indicus* is also notable in that while it has developed its own specialities in many features it combines in it many morphological characters of both *Archinotodelphys* and *Pararchinotodelphys* thus making it difficult to assign it to either of the two genera. One gets the impression that if the the present species does not represent a new genus the only other alternative will be to place all the four known species in a single flexible genus, *Archinotodelphys* Lang. It is probably more convenient and reasonable to treat the known four species as representing a single old genus with tendencies to specialize in various directions rather than to treat them as already specialized entities. The genus, in such a case, will combine in it all the characters of the family Archinotodelphyidae. However this procedure is not adopted here for the male is still unknown for the three earlier species. The degree of geniculation of the male antennule is an important criterion of generic distinction amongest the copepods and therefore, we have to await the descriptions of the males of these earlier species before proposing a merger of the existing genera as well as the present species into a single genus, *Archinotodelphys* Lang (1949).

Morphological specialities of N. indicus—In all the discussions of the comparative morphology of the three earlier species and the present one, the male is omitted for, it is not known in the former cases. The fusion of the cephalosome and the first pedigerous segment is already discussed. In the antennule there are only fifteen segments in the female and fourteen in the male on both right and left sides. The female antennule is 17-segmented in *Archinotodelphys* and 16—or 17—segmented in *Pararchinotodelphys*. In the antenna the structure of the terminal claw deserves some attention. In *P. phallusiae* it is described as one among the setae ' which in reality is somewhat small spiniform and very curved hook ' (Hansen, *loc. cit.* p. 5). In the diagram it appears to be hardly one-third the length of the last anternnal segment. In *P. gurneyi* it is moderately long, having the same length as the terminal antennal segment. A similar situation is found *A. typicus*. In all these cases the claw is rather weak. In *N. indicus* it is very strong and stout, being as long as the third and fourth antennal segments combined ; and it has got a characteristic curved posture. It may also be noted that the distal two setae are similarly curved and are of the same length as the claw while the proximal three setae are only less than half the length and possess no special bent.

Fifth leg of *A. typicus* is very short, only about one and a half times as long as wide and carrying three apical and one middle seta. Basal segment does not bear any seta. In *P. phallusiae* too it is short, distal segment about two times as long as wide and carrying two apical and two subapical setae ; the basal segment also carries a seta. In *P. gurneyi* the fifth leg is fairly long, the distal segment being about three times longer than wide and carrying two apical, one sub-apical and one middle seta ; the basal segment bears one seta. In all these cases the fifth leg is more or less cylindrical and the setae borne by it are as long as or a little longer than the distal segment. In the present case there is great difference in the dimensions of the proximal and distal segments of the fifth legs. While the proximal segment is very

broad at the base tapering gradually to the distal tip, a reverse state is found true in the case of the distal segments : a narrower basal region increasing in breadth to the distal part. Further two of the setae borne by the distal segment are very long, one of them being about three times longer than the entire fifth leg and the other a little shorter.

In the structure of the caudal rami, *N. indicus* differs from all the three other species ; while it is at least one and half times as long as the last abdominal segment in all the earlier species, it is hardly as long as the last abdominal segment in the present case. Further while in the known species the setae on the ramus are fairly long, some of them being as long as or longer than the ramus itself, it is very much shortened in *N. indicus* : the longest seta is just half the length of the caudal ramus.

Resemblances with Archinotodelphys—In *Archinotodelphys* the basal segment of the antenna is with two juxtaposed setae on the outer distal angle and with one seta on the inner angle. In the two species of *Pararchinotodelphys* there is only one fine seta instead of the two juxtaposed ones. However, in *P. phallusiae* a stout seta is borne separately at the inner angle. In *N. indicus* the condition is similar to that of A. *typicus* but the separate seta on the inner angle is lacking.

Illg (*loc. cit.*) has pointed out the possibility of differences at generic level in the armature of maxillule. It is doubtful whether any set limit can be placed at generic level on the structural pattern of maxillule in the family Archinotodelphyidae. However, the maxillule of the present species resembles very much that of *A. typicus*. In a sense *P. phallusiae* also approximates with that of *A. typicus* in the structure of the maxillule. The condition in the former may well be considered somewhat intermediate between *P. gurneyi* on the one hand and *A. typicus* and *N. indicus* on the other.

In *P. gurneyi* the maxilla is 6-segmented, the first two basal segments bearing two setiferous endites each. The third segment as in all other known species of this family is produced into a strong spine. There are four free segments in the distal region. In *P. phallusiae*, however, the situation is different : the two basal segments are fused and together bear four endites. The process of fusion has extended to the distal region also where all the four segments are fused together forming a large segment bearing a number of setae. The middle segment bearing the spine is, however, quite distinct. In *A. typicus* the two basal segments are fused and together bear four endites ; the distal region, however, is 2-segmented. Thus, in the case of maxilla also the present species has more kinship with *Archinotodelphys*.

Resemblances with Pararchinotodelphys :—In the number of segments of the urosome *N. indicus* approximates more with the species of *Pararchinotodelphys*. In these, it is 5-segmented and consists of the fifth leg-bearing segment, the genital segment and three abdominal segments, the last of which bears a pair of caudal rami. This is an important criterion on which *Archinotodelphys* is separated from *Pararchinotodelphys* and which the latter shares with *N. indicus*.

The structure of the maxilliped in *N. indicus* resembles that in *Pararchinotodelphys*. In both species of this latter genus it is 3-segmented as it is in the present case. The similarity is found also in the number of setae borne by different segments.

Notes on the family Archinotodelphyidae—Lang (*loc. cit.*) thus defined the family Archinotodelphyidae : ' General form as in *Cyclopinella* G. O. Sars. First leg-bearing segment free. Antennae with one apical claw accompanied by a number of

setae. No brood-pouch, the eggs being carried in two dorsal sacs.' It is obvious that in order to receive *N. indicus* into this family an important alteration is to be made in its definition. The archinotodelphyids are distinguished from the cyclopinids by the presence in the former of a claw on the terminal antennal segment : they are separated from the notodelphyids by the facts that eggs are carried in two dorsal sacs and that no known notodelphyid antenna shows the sub-division of the terminal portion into the clear cut segments found throughout the archinotodelphyids. The fused or free state of the first pedigerous segment cannot be considered as a character of the family for in *N. indicus* it is fused with the cephalosome while in all earlier species it is free from the latter. In the fusion of the cephalosome with the first pedigerous segment and in the extremely high development of the terminal hook of the antenna, *N. indicus* tends more towards the notodelphyid pattern than any other related species. The cyclopinids is thought of as the parental stock and the notodelphyids as the descendant group ; the archinotodelphyids are somewhat intermediate but aberrant group and 'the group as a whole exhibits a complex of primitive and advanced characters with no one member corresponding to the demonstrable archetypical requirements.' The discovery of this new species, *N. indicus*, with many morphological deviations and combinations as well as a profound change in the host preference probably adds to the complexity of the problem of their evolutionary lineage.

The following key to the identification of the various genera and species is rendered in compliance with the systematic procedure adopted in this paper ; however, the male is omitted from the key.

KEY TO THE IDENTIFICATION OF FEMALES :

1. Prosome consists of a cephalosome and four free leg-bearing segments ; host is an ascidian 2

   Prosome consists of a cephalothorax, formed by the fusion of the cephalosome with the first leg-bearing segment and three free leg-bearing segments : host is a mollusc..... .....*Nearchinotodelphys* g. nov. (only one species, *N. indicus* sp. nov. is known).

2. Urosome consists of six segments : the fifth leg-bearing segment, the genital segment and four free abdominal segments ; basal segment of the antenna carries two juxtaposed setae.....*Archinotodelphys* Lang, 1949. (only one species, *A. typicus* Lang, 1949 is known).

   Urosome consists of five segments : the fifth leg-bearing segment, the genital segment and three free abdominal segments ; basal segment of antenna carries only one seta instead of the two juxtaposed ones.....*Pararchinoyodelphys* Lang, 1949.

   The genus consists of two species :

   Antennule 17-segmented ; maxilla 3-segmented ; the terminal segment of the endopod of fourth leg bears two inner, one terminal and one outer setae (as shown in the figure) .....*P. phallusiae* (Hansen, 1923).

   Antennule 16-segmented ; maxilla 6-segmented ; the terminal segment of the endopod of fourth leg bears two inner, two terminal and one outer setae..... *P. gurneyi* Illg, 1955.

SUMMARY

Nearchinotodelphys indicus, a new genus and species of cyclopoid copepod, belonging to the family Archinotodelphyidae, is described in detail. Only three other species have so far been assigned to this family, all of them being known only from the female sex. *N. indicus* is represented by both the sexes.

The points of similarities and differences between the known representatives of Archinotodelphyidae are discussed briefly : *Nearchinotodelphys* differs from both *Archinotodelphys* Lang and *Pararchinotodelphys* Lang in a number of characters but also combines in it many other features of both these latter genera.

The cephalosome and the first pedigerous segment are free in all the earlier species whereas they are fused in *N. indicus*. Further while the ascidian has been the host of the earlier forms, *N. indicus* is harboured by a mollusc. These characters have been incorporated in the definition of the family Archinotodelphyidae.

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STUDIES ON INDIAN COPEPODS 4. DESCRIPTION OF THE FEMALE AND A REDESCRIPTION OF THE MALE OF *PSEUDODIAPTOMUS ARDJUNA* BREHM (COPEPODA, CALANOIDA) WITH NOTES ON THE DISTRIBUTION AND AFFINITIES OF THE SPECIES*

By A. N. P. Ummerkutty

Central Marine Fisheries Research Station, Mandapam Camp

In 1953, Brehm described a new species of calanoid copepod, *Pseudodiaptomus ardjuna* from Salsette Island, Thana District, Bombay. He had at his disposal only two male specimens, one of which was damaged. However, he could rightly identify it as a new species of the genus *Pseudodiaptomus* Herrick and gave a brief description of the male. The female of this species has not so far been described and there is no subsequent report of the male itself from anywhere. This short paper is meant to give a full account of both male and female collected from the South-East coast of India, off Mandapam.

The present study is based on the examination of numerous specimens obtained from the plankton hauls, in the Gulf of Mannar and the Palk Bay ; samples were also obtained from the saline creeks leading to the Central Marine Fisheries Research Station Experimental Fish Farm. No morphological differences were noticed between the three examples ; however, the present material differs in some details from the descriptions and diagrams given by Brehm for the specimens he collected from Bombay waters and these differences are discussed below. In describing the various parts of the body, I have adopted the terminology suggested by Gooding (1957) with some modifications (Ummerkutty, 1960 & 1960*a*). In presenting the ornamentation of the swimming legs Sewell's suggestion (1949) to differentiate spines by Roman and setae by Arabic numerals is adopted.

All the drawings are made with the aid of a camera lucida.

Genus *PSEUDODIAPTOMUS* Herrick

Marsh, 1933, p. 46.

Sewell, 1956, p. 167.

Wilson, 1932, p. 101.

PSEUDODIAPTOMUS ARDJUNA Brehm

Brehm, 1953, p. 313.

Female

The body (Fig. I, 1) is rather narrow, smoothly rounded anteriorly. The prosome consists of five segments. The first segment is the cephalothorax, formed

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by the fusion of the cephalosome and the first leg-bearing segment ; it is the longest of prosomal segments and is widest at its posterior margin. The second segment is rectangular with the long axis being the width of the copepod body. The third and fourth segments are rather short and subequal ; the latter is, however, wider than the former and is the widest part of the prosome. The fifth prosomal segment is armed on each of its postero-lateral corners with a sharp spine, directed backwards and slightly outwards ; the right spine is slightly larger than the left one. The urosome consists of four joints, the genital segment and three abdominal segments. The genital segment is barrel-like and exceeds other urosomal segments both in length and width ; it has a well-marked ventral swelling on which is borne the genital operculum ; the latter does not bear any spine. The abdominal segments are subequal, each segment being about half as long as the genital segment. The caudal rami are narrow, cylindrical and more or less parallel. It is one and a half times longer than the last abdominal segment and bears numerous setules on its inner margin. Each ramus bears five setae, four of which are apical and one subapical on the outer side.

The antennule (Fig. I, 2) is moderately long reaching the posterior margin of the prosome. It has 23 segments which bear the following proportions (all measured through midline).

1	2	3	4	5	6	7	8	9	10
5.5	4.1	3.0	3.4	3.3	1.7	3.0	4.1	2.2	3.1
11	12	13	14	15	16	17	18	19	20
4.5	4.5	5.3	5.9	6.0	6.0	6.9	5.4	4.3	4.3
21	22	23							
4.3	4.1	5.1	=100						

Segments 1st to 15th and also the 18th and the 23rd segments bear each an aesthetask besides one or more setae ; the aesthetask is short, but very distinctly developed. The 21st segment bears a specialized seta whose inner margin carries a row of teeth at about its mid-region. This last character is also met with in a number of other species of this genus (Sewell, 1932. p. 239). The antenna (Fig. I, 3) has the usual characters of the genus : a 2-articled protopod, a 2-segmented endopod and a 4-segmented exopod ; it, however, differs from others in possessing two rows of small spinules on the distal inner margin of the last segment of the endopod. The mandibular palp (Fig. I, 4) is with 4-segmented exopod, 2-segmented endopod and a 2-segmented protopod ; the masticatory blade normal with numerous teeth. The maxillule (Figl I, 5) is probably the most conservative of all structures in this genus ; it is quite normal and typical in the present species. The maxilla (Fig. I, 6) is apparently 3-segmented but consists of 7 endites, the first and second segments with 2 endites each and the third with 3 endites ; the endites bear 3 or 4 fairly long setae. The maxilliped (Fig. I, 7) is 7-segmented ; first and second segments are quite large and subequal and other segments are much smaller and their combined length is a little less than that of either first or second segment ; the first segment bears 7 setae and a spine ; the second only 3 setae and a number of minute hairs ; and each of the distal 5 segments bears two or more setae.

The four pairs of swimming legs (Fig. I, 8, 9 and 10) are borne by the first 4 prosomal segments. All the legs are biramous and constructed on identical plans.

While the second and third legs resemble each other in all the structural details, the first and fourth segments show differences both in size and in setation. The ornamentation of the swimming legs are as follows :

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P_1	1	0	0	0	1	0	1	0	3	2	1	1	I	1	0	3	I	II
P_2	1	0	0	0	1	0	2	0	4	2	2	1	I	1	I	5	I	II
P_3	1	0	0	0	1	0	2	0	4	2	2	1	I	1	I	5	I	II
P_4	1	0	0	I	1	0	2	0	3	2	2	1	I	1	I	5	I	II

It may be seen that the terminal exopod segment of each leg is provided with two outer spines and that the other exopod segments each bears a single outer spine except the second segment of the first pair of legs which has no spine at all. There is a single inner seta on the first and second segments of each exopod. The terminal exopod segment of first legs bears 3 setae while the second, third and fourth legs bear each 5 setae on this segment. The first endopod segment in all the four pairs of legs each carries a single seta while the second segment in these legs carries 1 seta in the first leg and 2 setae each in the next three legs. The terminal endopod segment in the first legs bears 6 setae, in the second and third legs 8 setae each and in the fourth leg 7 setae. The basal protopod segment carries a single seta in all the four legs, while the second protopod segment does not bear any seta or spine except in the fourth leg where a small spine is present.

The fifth legs (Fig. I, 11) are uniramous, symmetrical and small. On each side it consists of 4 articles ; the first segment is devoid of any seta or spine ; second and third segments each bears a single setule ; the last segment bears 2 setae of unequal length and 2 flattened spinelike structures, bearing minute teeth on the inner margin. In this genus the basal two segments of the fifth leg represent the protopod and the distal two segments the exopod ; the endopod is entirely lacking.

The female carries a single ovisac, rather irregular in shape and containing about 25 eggs. Length of the female is 1.31 mm.

Male

The male (Fig. I, 12) shows sexual dimorphism in the antennule, the fifth pair of legs and in the urosome. It is smaller than the female but has the same general appearance. The spines on the posterior prosomal segments are, however, much less pronounced, although their slight asymmetry is maintained. The urosome is 5-segmented, of uniform width and more cylindrical than in the female ; first segment is the shortest and second the longest while other three segments are subequal and of moderate length.

The right antennule (Fig. I, 13) is geniculate while the left is quite normal and resembles that of the female in all structural details, including the specialized seta

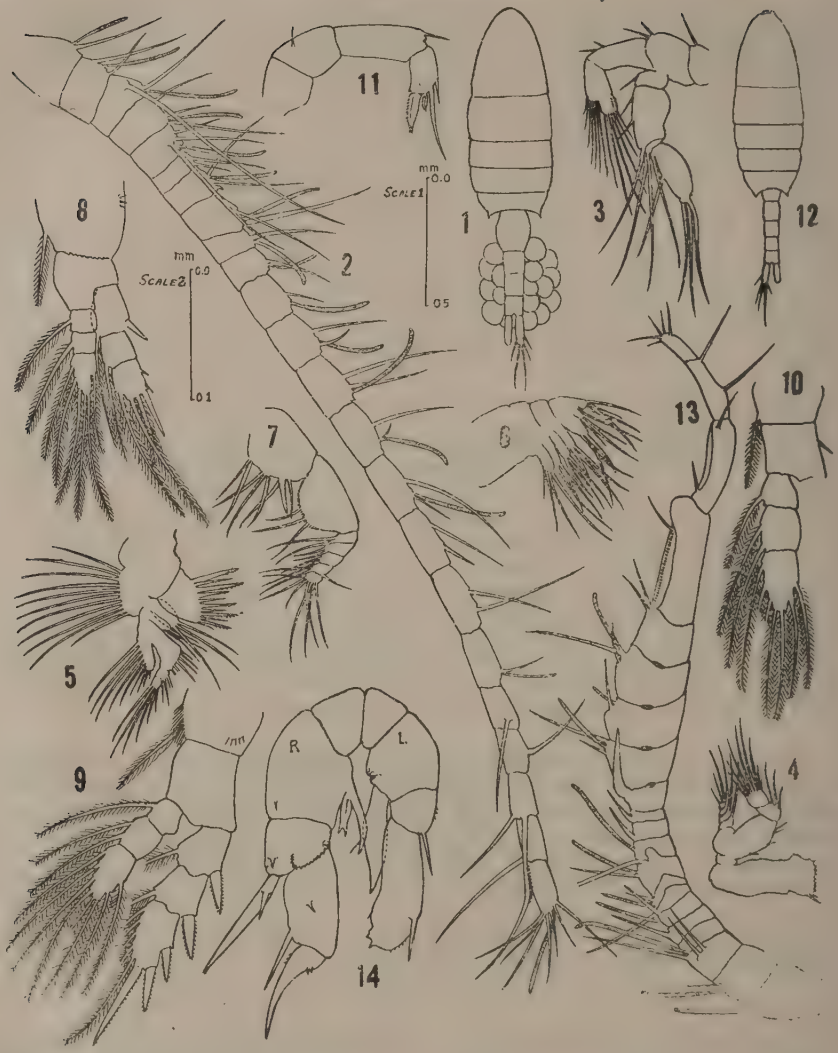

FIG. I, 1-14 : *Pseudodiaptomus ardjuna* Brehm.

1. Adult, egg-carrying female, dorsal view.
2. Female, antennule
3. ,, antenna
4. ,, mandible.
5. ,, maxillule
6. ,, maxilla.
7. ,, maxilliped.
8. ,, first swimming leg.
9. ,, second swimming leg.
10. ,, endopod of fourth swimming leg.
11. ,, fifth leg.
12. Male, adult, dorsal view.
13. ,, ,, geniculate antennule.
14. ,, ,, fifth pair of legs.

of the twenty-first segment. The geniculate antennule consists of 21 segments which bear the following proportions :—

	1	2	3	4	5	6	7	8	9	10
	7.8	5.5	4.2	2.4	1.8	2.1	2.1	1.7	2.5	2.4
11	12	13	14	15	16	17	18	19	20	21
2.1	1.2	3.5	5.1	5.6	6.0	5.8	12.8	11.8	8.5	5.1=100

As the lines of separation are not exactly parallel in all cases and as the measurements are done through the midline of the segments, the proportions given for some segments are not accurate. The segments from 1st to 16th each bears an aesthetask, except the fifth, seventh and eleventh to thirteenth segments ; the latter 3 segments, however, each bears a stout spine.

Fifth legs (Fig. I, 14) are rather strongly built, asymmetrical and close together ; the right leg is slightly longer than the left ; right basal one is, of moderate size with no accessory process ; basal two is very large and slightly longer than wide ; it carries on its inner margin a ' y '-shaped spinous process with the arms of unequal length ; this process represents the vestigeal endopod ; it also carries at its distal outer corner a small spine on the anterior face. Exopod is displaced into medial line and consists of 3 segments ; the first segment is fairly large and much wider than long ; three features are notable in this segment : (*a*) at the distal outer angle there is a spinous process which is quite long and which, in its turn, bears a smaller spine at one-sixth of its proximal length, thus giving a forked appearance to that region ; (*b*) a small, almost conical spine, also borne on the distal outer corner, is present just below the preceding larger spine ; and (*c*) a serrated edge is seen along the line of separation of the first and second segments ; this edge curves down after the mid-width of the segment. The second exopod segment is much longer than the first segment but distinctly less wide ; it carries a fairly long spine on its distal outer angle and a smaller spine at about the centre of the segment on the anterior face. Exopod segment 3 is modified into a stout spine ; its base is bulbous, bearing a few spinules on either side.

Left basal one is smaller than its right counterpart and with no accessory spines or processes. Left basal two is quite large with its breadth larger than the length. It bears at its inner distal angle a digitiform process which is fairly long almost equivalent to the length of the entire protopod. This process probably represents the endopod. In the left side, too, the exopod is displaced to a medial line and consists of only two segments ; the first segment is quite short, the greatest length and breadth being almost equal ; it bears a sharp spine at its latero-distal angle ; the second segment consists of a thin plate, more or less rectangular in shape ; on its outer margin it bears a spine at two-third of its length and a few minute spinules after that ; on the left side the distal margin is provided with three spinules borne on small projections.

In the structure of other appendages and legs the male is identical with the female except in the smaller proportionate sizes. The length of the male is 1.1 mm.

A redescription of the male is provided above as it is found to show some variations in the structural details of the fifth legs from those of the specimens described by Brehm (*l. c.*). The basal II of the right leg, in Brehm's diagram is shown to have a digitiform process, instead of the ' y '-shaped process seen in the present

specimens. The bifurcated spines on the outer distal angle of the basal exopod segment of the right fifth leg in Brehm's diagram appears to be only a different view of the same shown for the present material. In the left leg the terminal exopod segment is flat and leaf-like in both ; but in Brehm's diagram the proximal part is shown to be only half as wide as the distal area, whereas in the present example it is more or less of uniform breadth throughout. It is possible that these differences are real and are probably geographic variations within the same species ; it is also possible that these apparent differences do not exist at all and that Brehm's specimens exhibit deviations only because they would have been mounted and examined in a different angle. However, I feel that the species dealt with in this paper is the same as that erected by Brehm from Bombay waters.

Distribution—Until now this species is known only from the Bombay coast. Its occurrence both in the Palk Bay and in the Gulf of Mannar, off Mandapam extends its distribution to the south-east coast of India. It is likely that a careful examination would reveal its presence all along the west coast and possibly the east coast. It is an inshore dwelling species and gets into the saline creeks that are connected to the sea. In the Gulf of Mannar it is found in good numbers during the late winter months; February and March, majority of the females at that time carrying egg sacs. Rare individuals are caught almost throughout the year especially in the very inshore waters. The saline creeks, referred to above are on the Palk Bay side. They experience great variations in the salinity and temperature not only from season to season but in the different hours of the same day, depending upon the level of water present in them. Specimens were caught in April and May when usually there would be a fair amount of water in the creek. There is no information available as to its presence or absence in other months. The specimens taken from the creeks appeared to be actively reproducing as shown by the large number of ovigerous females and naupliar and copodite stages.

Notes on the affinities of the species—The genus *Pseudodiaptomus* was established by Herrick in 1884 to receive a brackish water species, *pelagicus*, taken in Mississippi Sound, North America. Although this species has not been subsequently recorded from anywhere, there has been a steady increase in the number of known species of this genus, the total number at present being thirty-six. Marsh (1933) divided the species of this genus, placing a number of them in an older genus *Schmackeria* Poppe and Richard, (1890) in which the 'second segment of the basipod of the left fifth foot of the male is armed ; and its inner border is with a long curved projection' ; and in which the last prosomal segment of the female is rounded. Johnson (1939) obtained a new species *euryhalinus*, from the California Coast and created a new subgenus *Pseudodiaptallus* to accommodate it, so that its 'close relationship to the known *Pseudodiaptomus* species is well expressed'. This subgenus is easily distinguishable by the presence of only two free segments in the urosome. Sewell (1956) regards all these, namely, *Pseudodiaptomus* (*s. str.*), *Schmackeria* and *Pseudodiaptallus* as three subgenera of Herrick's original genus *Pseudodiaptomus* (*s. lat.*). However, the distinctions between *Pseudodiaptomus* (*s. str.*) and *Schmackeria* still appear to be far from clear, if there is any difference at all. If we accept Marsh's contention that *Schmackeria* has a vestigeal endopod in the form of process, spine, etc., in both right and left legs of the male and has the posterior corners of the prosome rounded in both sexes, in contrast to *Pseudodiaptomus* (*s. str.*) which is said to have the vestigeal endopod only in the right fifth leg of the male and to have the posterior corners of the prosome angular, it appears that some of the species are not assigned to their proper systematic places. *Pseudodiaptomus salinus* Giesb. and *P. hickmani* Sewell, both recorded from Indian waters, for example,

possess a vestigeal endopod in both right and left male fifth legs ; Sewell, however, lists them in the subgenus *Pseudodiaptomus*. They can certainly be included in that subgenus if we take into account only the angular nature of the posterior corners of the prosome ; in the structure of the male fifth legs their affinities are with *Schmackeria*.

The present species is very closely related to *P. hickmani* and *P. salinus*. The fifth legs, both in the male and in the female are very identical in all these species and differ from each other chiefly in the proportionate dimensions of the constituting parts. Whether all the three species should be placed under the subgenus *Pseudodiaptomus* or the subgenus *Schmackeria*, it is not clear in the light of the present definitions given to the two groups. The genus has grown very large and the bizarre addition of the new species from time to time, many of them inadequately described, necessitates an urgent revision of the genus.

Summary

The unknown female of a calanoid copepod *Pseudodiaptomus ardjuna* Brehm is described. A redescription of the male also is rendered as it is found that a few differences of structural details exist between male fifth legs of the present specimens and the male fifth legs described and sketched by Brehm (1953).

The systematic kinship of the species is briefly considered. It is very close to *Pseudodiaptomus salinus* and *P. hickmani*. A note is also given on the distribution of the species in the light of our present knowledge.

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CILIARY CURRENTS AND ASSOCIATED ORGANS OF *MARTESIA FRAGILIS*, A WOOD BORING PHOLAD OF MADRAS[1]

By V. V. Srinivasan

Zoology Research Laboratory, University of Madras

Introduction

The ciliary feeding currents and their associated organs of bivalve molluscs have been extensively studied both morphologically and experimentally (Ridewood, 1903; Wallengren, 1905 ; Kellogg, 1915 ; Yonge, 1923, 1926b, 1928 ; Atkins, 1936, 1937, 1937*a*, 1937b, 1938, 1938*a*; Purchon, 1941, 1955). Among the wood boring lamellibranchs, such a study has been carried out on Teredines like *Teredo navalis* (Sigerfoos, 1908) and *Bankia indica* (Nair, 1957). The gills in these forms are highly reduced and do not possess any ciliary mechanisms for sorting waterborne food items. Purchon (1941) has demonstrated a similar condition in the pholad *Xylophaga dorsalis* while he found five species of rock-boring pholads (*Barnea parva*, *Pholadidea loscombiana*, *B. candida*, *Pholas dactylus*, *Zirphaea crispata*) possessing well developed ctenidia and ciliary currents capable of sorting food material. Purchon infers that the well developed ctenidia with food sorting mechanisms are associated with their plankton feeding habit. The only other pholad known to be wood boring is *Martesia* sp. of which two are known to occur in Madras waters ; *M. striata* and *M. fragilis* and these wood boring pholads appear to feed exclusively on plankton. It was felt that a detailed study of the ciliary sorting currents and the anatomical features of the mantle, the siphons and the ctenidia of *M. fragilis* will be of interest by itself and for comparison with other rock-boring pholads.

Material and Methods

About 1500 living specimens of *M. fragilis* were obtained both from test planks submerged in the sea and from small wooden pieces and drift logs washed ashore on the Madras beach. The course of ciliary currents were studied in live specimens with the help of mercuric chloride and carmine particles suspended in the water. Sections of the entire body were cut using Bouin's fluid, Altmann's fluid and Zenker's fluid as fixatives.

The mantle and the siphonal process

The mantle on either side of the body is fused with each other subterminally so that ventrally there appear to be three lobes, the free edges of the mantle on either side and the fused middle part. The mantle cavity so formed is bounded dorsally by the visceral mass and contains the gills and the foot. In the young forms of *M. fragilis* as in the young of *Barnea parva*, *P. losombiana* and *Pholas dactylus* the incomplete fusion of the mantle lobes leave the pedal aperture, while in the adults, this

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aperture is closed resulting in the separation of the foot. However in the adults of *B. parva* and *P. dactylus* the pedal aperture remains as such, enabling the foot to be protruded throughout their life. The free edge of each mantle shows three thickenings on the inner surface.

Histology

In a transverse section passing through the ventral edge (Fig. 1) the epidermal cells of the outer (OM) and inner lobes (IM) are found to be columnar with darkly staining nuclei. The cells of the inner lobes are ciliated interspersed with mucus cells staining with acid fuchsin. Beneath the epithelium is the connective tissue (CT) staining with aniline blue, penetrated by muscle fibres (MF). The epithelium of the middle lobe (MM) consists of flat irregular cells with distinct nuclei and considered to be secretary in function, while the inner surface has an epithelium composed of cells which are longer than those of the inner lobe and these are non-ciliated. The mantle lobe on either side of the body shows three layers ; an outer columnar epithelium with oval nuclei arranged towards the basal half, an inner epithelium of ciliated cells facing the mantle cavity with mucous glands (MUG) interspersed between the ciliated cells (Fig. 9). These cilia are of uniform length measuring 13 μ and are distributed all over the inner surface of the mantle. In *Xylophaga dorsalis* the major portion of the mantle is unciliated and in *Teredo norvegica* the cilia are found in scattered groups. The middle layer is of loose connective tissue, which is filled with numerous lobed spaces and traversed by muscle bundles staining dark red in acid fuchsin.

Siphons

The siphonal process is a slender backward prolongation of the fused mantle and its cavity. Of the three thickenings on the inside of the mantle the inner, middle and inner margins of the outer lobe become included in the siphonal process. Therefore the siphonal process of *M. fragilis* belongs to Type C (Yonge, 1948) like those of the rock-boring pholads and *Xylophaga dorsalis* (Purchon 1941, 1955). The siphonal process (Fig. 2) is long, delicate pale brown in colour, the outer surface of which is smooth. The walls are contractile and the process can be withdrawn within the valves which are slightly bulged for their retraction. Inside, the siphonal process is subdivided distally into a dorsal exhalent and ventral inhalent siphon (IS & ES) which are both encircled by a mantle sheath which forms a delicate rim close to the siphonal apertures as in *P. loscombiana*. The rim bears about 54 tentacle-like processes of which 34 are longer. In addition there are two very long tentacles situated on the wall of the siphonal process proximal to the rim. The entire rim and the inner surface of all the tentacles are dotted with brownish and whitish pigment spots, which are considered to be the openings of pigmented glands (Johnstone, 1899). Both the inhalent and exhalent tubes are united upto the siphonal rim and beyond it they are free.

The inhalent aperture is borne on a long slender funnel which is guarded by a variable number (usually six) of tentacles projecting across the aperture. There are also some very small tentacles which curve slightly inward to cover the inhalent aperture. In *Xylophaga* the circular aperture of the inhalent siphon is fringed with about 6 delicate tentacles.

The inhalent siphon extends far beyond the exhalent siphon and is 3 mm. to 14.5 mm. long measuring from the rim in specimens of length ranging from 3 to 10 mm. The exhalent siphon is not so retractile but can be closed in such a way as to form a cone at its tip. The outside and inside of this funnel is of a brownish hue

with scattered whitish spots on the outer surface. During excretion the exhalent aperture is closed and opened at intervals of 20 to 40 seconds.

Histology

In a section across the wall of each siphon (Fig. 3) we find the outer wall is reinforced by the common sheath and is of the same structure as the outer mantle epithelium. On the innerside the epithelium is of cubical ciliated cells. Between the two epithelia the connective tissue is traversed by four groups of muscle fibres two being longitudinal (LM_1 & LM_2) and two circular (CM_1 & CM_2) arranged alternately. These muscle fibres are responsible for the greater contractility of this siphonal extension of the mantle. The gross as well as minute structure of the mantle and siphonal process of *M. fragilis* are very closely similar to those of other pholads (*B. parva*, *P. Loscombiana*, *B. candida*, *Z. crispata*, *P. dactylus* and *X. dorsalis*, Purchon, 1941 & 1955), Teredines (*T. norvegica*, Lazier, 1924; *B. indica*, Nair, 1957) and *Cardium* (Johnstone, 1899).

The Ctenidia

The ctenidia (Fig. 4) of *M. fragilis* consist of two pairs of creamy white demibranchs one on each side of the visceral mass, extending from the labial palp anteriorly to the middle of the siphons beyond the hinder border of the valves (Fig. 5). The ctenidium measures 7 mm. in a specimen of 8.5 mm. long and nearly two-thirds of the ctenidium lies behind the visceral mass. The two demibranchs of a side are approximately equal in depth posteriorly but anteriorly the inner demibranch is deeper and extends upto the base of the labial palps. In this respect *M. fragilis* resembles the rock-boring pholads and differs from *Xylophaga* in which the ctenidium is greatly reduced having only the direct lamella of the outer demibranch. The axes of the two ctenidia meet in front of the inhalent siphon.

Each branchial filament is V-shaped so that owing to the serial arrangement of the filaments on the axis there is a groove formed along the margin of the gill. The gill especially on the inner demibranch is so shaped that the filaments become shorter at the anterior end of the axes and the marginal groove opens at the front end of the gill between the two palps close to the mouth. In *M. fragilis*, unlike what obtains in *P. loscombiana* and *B. candida*, the outer demibranch also has the marginal groove which opens like that of the inner demibranch but farther away from the mouth. However, in *Xylophaga* all the demibranchs are devoid of marginal grooves. The inter lamellar septa which occur at intervals of 10 to 13 filaments are thick junctions extending vertically from the margin upto the axis and contain the vertical blood vessels which are connected by horizontal vessels running in the subfilamentar tissue where the different filaments are fused along the axis. The suprabranchial chamber formed by the mantle above the axis and filaments of each gill are long cylindrical median canals running dorsal to the visceral mass. Anteriorly where the gills are more slender and confluent with the labial palps, these chambers become very slender canals in the substance of the mantle.

Transverse sections passing through the epithelium of each branchial filament (Fig. 6) reveal the presence of the ciliated, non-ciliated and the secretory cells. Three cells with short cilia measuring 3 μ are located in the frontal area of the filament. There are two laterofrontal cells bearing long cilia. The cilia of the adjacent branchial filaments interdigitate. These laterofrontal cells are tall measuring 8 μ containing nuclei which stain dark red with acid fuchsin. The non-ciliated cell layer separates the laterofrontal cells and the lateral cells and is made up of three cubical ciliated cells containing large oval nuclei. The wall of the epithelium

posterior to the lateral cells consists of a single layer of non-ciliated cells containing small nuclei. Internally the filament is filled with loose connective tissue. In sections blood vessels are seen to pass through the filament. The secretory cells (SEC) occur between the epithelium. They are typical mucous cells.

The Ciliary currents

Currents over the mantle surface.—The course of water currents in the mantle cavity have been shown diagrammatically in Fig. 7. The water which enters the inhalent siphon bears particles of suspended matter. Water and very fine particles pass from the mantle cavity into the gills whereas large and heavy particles which cannot enter the branchial meshes are sent out through the inhalent aperture by which they enter as 'pseudofaeces'. Thus the cilia occurring on the inner side of the mantle (*vide* supra) are responsible for a strong current or ciliary movement which take the large particles to the mantle margin. Powerful rejection tracts arise near the antero-ventral end and runs backwards close to the mantle margin carrying with it particles entangled in mucus backwards to the base of the inhalent siphon. The cilia responsible for this movement being on the lower margin, do not interfere with the circulation of water along the upper and middle region of the mantle cavity. The heavier particles which sink down to ventral mantle edge by gravity therefore do not travel with the rest of the water current. The water currents are set up by the beat of the cilia on the rest of the mantle surface principally in the upper part of the mantle chamber from the inhalent siphon extending up to the anterior end. As the water flows along the upper margin of the chamber the particles are conveyed downwards over the surface of the gills by the vertical rows of cilia on them. In *Xylophaga* the major part of the mantle is unciliated and particles are efficiently removed under normal conditions by ctenidia (Purchon, 1941) and in *T. norvegica* (Lazier, 1924) the scattered groups of cilia on the mantle beat towards the ciliated mantle tracts and assist in keeping the surface of the mantle clean. In both of these forms the cilia of inner surface of the mantle which are restricted to the mantle tracts serve to limit the quantity of food particles which are passed from the ctenidia to the mouth.

Branchial currents.—The course of water currents over the gills have been shown diagrammatically in Fig. 5. Since the gills are filamentary the water in the mantle cavity can gain entry into the inter lamellar space through the space between the successive filaments. This is facilitated directly by the laterofrontal cilia which move anteroposteriorly and directly by the lateral cilia moving the water within the lamella upwards into the suprabranchial chamber and thus taking the water in. The frontal cilia beat towards the margin of the gill so that the water which has not entered the upper levels of the gill filaments are made to enter through the middle and ventral areas of the gill surface. The water which continues to enter the suprabranchial chamber is forced through the exhalent siphon by the beat of the cilia in the suprabranchial chamber. In short the entire circulation through the gills is designed to draw water in the mantle cavity through the inhalent siphon.

As already mentioned before the very large and heavy particles of matter nutritive or otherwise which may enter the inhalent siphon fall by gravity to the ventral region of the pallial cavity and are pushed backwards through the inhalent siphon by which they enter. The medium size and finer particles which are moved along the incurrent water reach the gills.

The medium sized and fine particles which fall on the surface of the gills are pushed from either sides of the filament towards the frontal surfaces by the for-

wardly beating long cilia belonging to the laterofrontal band. They come under the action of the downwardly beating frontal cilia and are swept down towards the marginal groove (Fig. 4) from where they travel forwards through the forward beat of the strong cilia of the marginal groove until they reach the lateral oral groove between the two labial palps. Larger particles were dropped over the surface of the mantle cavity. The very fine particles which enter the gill through filaments are carried out of the body. On all lamellae of the ctenidia currents move ventrally to the margins, where material is received into the grooves. *M. fragilis* is identical with *B. parva*, *P. dactylus* and *Z. crispata* in this respect. Hence *M. fragilis* falls into the ctenidial category C_2 of Atkins (1937*a*). However in *B. candida* and *P. loscombiana*. marginal groove is present at the free edge of the inner but not of the outer demibranch. So they fall under the type C_1 of Atkins (1937*a*).

Currents over the labial palps.—Labial palps were removed and pinned on to a board. Ciliary currents over the palps were observed and are indicated diagrammatically in Fig. 8.

The labial palps of *M. fragilis* are small possessing few large transverse ridges. When carmine particles are applied to the palps it is noticed that some particles are swept downwards in the groove between the folds of the palp. There the cilia beat ventralwards and particles pass out of the groove and reach the anteroventral end of the palps. From here they pass backwards to the tip of the palps and then fall on the floor of the mantle from where they are taken outside the mantle chamber by the currents of the mantle. These currents which remove the rejected material from the mantle are called the 'rejection currents' (Purchon, 1955). The finer particles are seen to be carried from fold to fold rapidly. These reach the anterior end of the palps and later lead towards the mouth. These currents are called the 'acceptance currents' (AC) (Purchon, 1955). In *M. fragilis* the medium sized and heavy particles fall into grooves between folds and are swept by rejection currents out of the groove centrally and later to the ventral margin of the palps. They are taken by the rejection currents on the mantle and swept towards the base of the siphon (Fig. 8). These together with heavy particles which are dropped down from the gills are expelled from the mantle cavity by the combined action of the cilia on the tracts and by the muscular action of the mantle, through the inhalent siphon as 'pseudofaeces'. The finer particles are carried by the acceptance currents from fold to fold towards the mouth. Similar acceptance and rejection currents have been described in plankton feeding *Barnea parva* and *Zirphaea crispata* (Purchon, 1955). In *Teredo megotara* selection is displayed only by rejection mechanism of the mantle and not by the labial palps. Sorting does not take place on the palps and all the material is passed to the mouth. This is probably due to its capacity to feed exclusively on wood fragments. However, in *X. dorsalis* (Purchon, 1941) the labial palps retain to a certain degree the power of quantitative selection. Over the greater extent of the surface of the labial palps the cilia beat outwards removing the particles from the labial palps. Only small quantities of food particles are taken to the mouth but larger quantities are removed by the outwardly beating cilia. This lends further support to the view held by Purchon (1941) that though *Xylophaga* derives nutriment from wood through which it bores, yet under certain circumstances it is independent of wood as a source of food.

Fig. 7. Shows the course of ciliary currents over the mantle surface. RSV : Right shell valve, ES : Exhalent siphon, IS : Inhalent siphon.

Fig. 8. Shows the course of ciliary currents over the right inner palp. AC : Acceptance current, RP : Rejected particles.

Fig. 9. Shows the transverse-section through the inner mantle epithelium. V ; Vacuole, MUG ; Mucous gland, C ; Cilia.

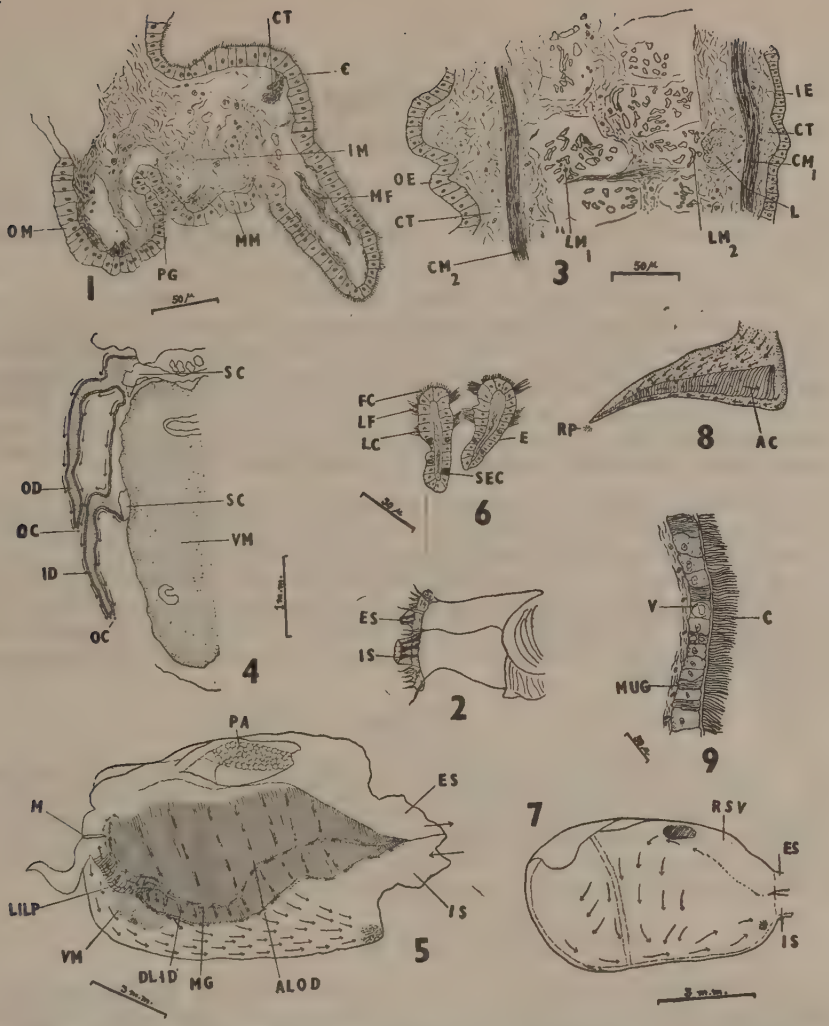

Fig. 1. Shows the transverse-section through the mantle edge. CT : Connective tissue, C : Cilia, IM : Inner mantle lobe, MF : Muscle fibres, MM : Middle mantle lobe, PG : Pericardial groove, OM : Outer mantle lobe.

Fig. 2. Diagram showing the inhalent and exhalent siphons. ES : Exhalent siphon, IS : Inhalent siphon.

Fig. 3. Shows the transverse-section through a part of the inhalent siphon. OE ; Outer epithelium, CT : Connective tissue, XM2 : Circular layer of muscles, LM1 : Circular layer of muscles, CT : Connective tissue, IE : Inner epithelium.

Fig. 4. Shows the transverse-section through the visceral mass, and ctenidia showing the course of the ciliary currents over the gills. OD : Outer demibranch, OC : Oralward current. ID : Inner demibranch, OC : Oralward current, VM : Visceral mass, SC : Suprabranchial chamber.

Fig. 5. Shows the course of ciliary currents over the gills. M : Mouth, LILP : Left inner labial palp, VM : Visceral mass, DLID : Descending lamella of inner demibrancn, MG : Marginal groove, ALOD : Ascending lamella of outer demibranch, IS : Inhalent siphon, ES : Exhalent siphon.

Fig. 6. Shows the transverse-section through two adjacent branchial filaments. FC : Frontal cilia, LF : Laterofrontal cilia, LC : Lateral cells, SEC : Secretory cells, E : Epithelium.

Remarks

In any assessment of the efficiency of filtering mechanisms of different borer it is essential to grade the sizes of particles and to locate the sites at which particles are rejected and to assume that the particles which are retained are digested in the gut.

Only very fine (20 μ) particles are seen all over the gills en route to the mouth. Since very few are rejected it is permissible to conclude that these small particles are injested and thus retained. Particles of medium and larger size are found rejected early in the course of the current unlike what is obtained in *Xylophaga* and Teredines. The sites of rejection in *Martesia* appears to be at the powerful rejection tracts over the mantle, at the marginal groove and at the rejection currents over the labial palps. The study of the ciliation and the structure of the gill and the mantle (*vide* supra) supports these observations regarding the retention of these particles.

In all these features and in the structure of the gills, mantle and the labial palps *M. fragilis* shows close resemblances to rock-boring pholads like *Pholadidea loscombiana*, *Barnea parva* and *Zirphaea crispata* which possess well developed plankton feeding mechanisms. It however differs from *Xylophaga* and Teredines in which the ctenidium and labial palps are highly reduced and which therefore lack a sorting mechanism. However, these forms are capable of controlling the amount of planktonic food carried to the mouth by virtue of their possessing ciliated rejection tracts over the mantle.

Summary

A detailed account of the structure of mantle, siphons and the ctenidia are given. These show a close resemblance to those of other rock-boring pholads. The ciliary mechanisms of the mantle and ctenidia which aid in its feeding on planktonic organisms are seen to be well developed and efficient. The labial palps play an important part in the grading of various sizes of food particles and reject all except the finest particles. Comparisons with *Xylophaga* and Teredines are made.

Acknowledgements

My thanks are due to Prof. C. P. Gnanamuthu, Director, Zoology Research Laboratory, University of Madras for suggesting the problem and for helpful suggestions and to Prof. G. Krishnan, for guidance. The work was carried out with funds provided by the Forest Research Institute and Colleges, Dehra Dun.

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Mar. biol. Ass. India, 1960, 2 (2) : 194-195

NOTES ON ANIMAL ASSOCIATIONS. 3. A PARTHENOPID CRAB, *HARROVIA ALBOLINEATA* ADAMS & WHITE ON A MARIAMETRID CRINOID, *LAMPROMETRA* SP.

By S. Jones and C. Sankarankutty

Central Marine Fisheries Research Station, Mandapam Camp

Instances of decapod crustaceans living in association with crinoids are known (Hyman, 1955) and from Indian waters one such example of *Galathea elegans* living in association with *Antedon* has been recorded by Southwell (1909) from Okha in the Gulf of Kutch. The same species of anomuran crab was reported from South Africa by Barnard (1950) as commensal on another crinoid, *Tropiometra carinata*. The brachyuran crab, *Harrovia albolineata* Adams & White, has already been recorded to live in association with comatulids by Serene *et al.* (1957-58) in the Gulf of Nhatrang, Vietnam. In this article an association between *H. albolineata* and *Lamprometra* sp. is recorded.

During one of the diving operations for collection purposes in comparatively shallow water at Vedalai near Mandapam in the Gulf of Mannar, a mariametrid crinoid belonging to the genus *Lamprometra** which was harbouring a female specimen of a parthenopid crab, *H. albolineata* was collected by one of us (C.S.) from a depth of about 2 metres. The crinoid was found attached to sea-grass with the crab at the aboral side close to the aboral cirri. The latter was well camouflaged in the above position and was hardly distinguishable on account of the similarity in the colour pattern of the symbionts (Plate I, Figs. 1 & 2).

The crinoid is smaller and paler than the common species occurring here and has white aboral cirri and brownish brachials with a white band along the periphery forming a discontinuous circle when viewed as a whole from above. The crab has conspicuous dark bands on the white background of the carapace and chelipeds matching well with the characteristic colouration of the crinoid (Plate, Figs. 3 & 4).

The animals, after collection, were placed in an aquarium for observation. When separated the crab would move about restlessly till it gets at the crinoid. The crinoid survived only for a couple of days, during which time, the crab was never seen to desert its host of its own accord ; but when the crinoid died the crab was found moving about at the bottom of the aquarium.

A specimen of *Harrovia albolineata* was collected from the above locality on an earlier occasion in a dredge along with the same species of crinoid. Evidently due to the disturbance caused by the dredging operation it had got dislodged from the host and was found free.

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* Identified by Mr. S. Mahadevan of the Central Marine Fisheries Research Station to whom our thanks are due.

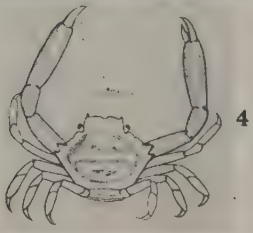

FIG. 1. Ventral view of *Lamprometra* sp., with the parthenopid crab, *Harrovia albolineata* Adams and White between the aboral cirri and brachials; FIG. 2. A portion of the above enlarged. The position of the crab is indicated by the arrow; FIG. 3. A photograph of *H. albolineata*. FIG. 4. A diagarm of *H. albolineata*.

In the absence of any factual data the nature of mutual benefit derived by the partners could only be a matter of conjecture. It is possible, that in return for the comouflaged vantage position and shelter the crab gets, the crinoid should be indirectly benefited in the procurement of food for itself.

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J. Mar. biol. Ass. India, 1960, 2 (2): 196-198

ON TWO DIATOMS FROM THE INSHORE WATERS OF PALK BAY*

By P. V. Ramachandran Nair

Central Marine Fisheries Research Station, Mandapam Camp

Observations on the occurrence and distribution of diatoms at Station **P** in Palk Bay have been made systematically since 1951 (Prasad, 1956). In 1957 March, two species of diatoms were noticed for the first time in the routine plankton collections. On detailed examination they were found to belong to the genera *Stictocyclus* (Family EUPODISCACEÆ) and *Cerataulus* (Family BIDDULPHIACEÆ). Since these two species are new records from the Indian coast (ref. Subrahmanyan, 1946 & 1958), the taxonomic account of them together with some remarks on their occurrence is given below:

Centrales

Family EUPODISCAEÆ

Genus Stictocyclus Mann

Stictocyclus appendiculatus (Grunow) Hustedt.

In Schmidt, A., *Atlas*, Pl. 433, Figs. 1-3, 1941.
(Plate I, Figs. 1-2)

Syn.: *Stictodiscus appendiculatus*, Van Heurck, 1880-1885, Pl. 118, Fig. 4. *Actinocyclus appendiculatus*, Rattray, 1890, p. 161. *Stictocyclus varicus*, Mann, 1925, p. 146, Pl. 32, Figs. 1-2. *Stictocyclus* (*Actinocyclus*) *varians*, Karsten, 1929, p. 226, Fig. 252.

Cells cylindrical, usually single, sometimes united in two. Valves circular. Valve surface almost flat and with numerous radiating ribs about 6 μ apart at the apparent rim and extending to the valve mantle. The two valves joined by the girdle forming a thick frustule. The ribs do not reach the centre. A hyaline 'eye' present, located 10 μ inside the rim. Valve surface areolate, Areolae in radial rows, 6 in 10μ. Girdle with 5 ring-like markings. Areolation on the girdle delicate, 13 in 10 μ. Chloroplasts small and numerous.

Length of pervalvar axis : 482 to 1020 μ.

Length of apical axis : 188 to 268 μ.

Distribution : Philippines, Miang Besar, Borneo, Java, Palk Bay (Mandapam).

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* Published with the kind permission of the Chief Research Officer, Central Marine Fisheries Research Station, Mandapam Camp.

Family BIDDULPHIACEÆ

Genus CERATAULUS Ehrenberg.

Cerataulus thermalis var. *sinensis* (Grun.) Forti forma *ceylonica* Skvortzow,

Ann. roy. bot. Gard. Peradeniya, **11**, p. 252, pl. 32, figs. 4, 6 & 7

(Plate I, Fig. 3)

Cells cylindrical, united in short, straight chains. Pervalvar axis elongated usually two to three times the diameter. Valves circular with four short rounded and slightly elevated processes. Valve mantle short, no constriction between the valve and girdle zones. Ring-like markings on the girdle. Areolae faint, in pervalvar rows on the girdle and slightly arching to the centre on the valve mantle, 12 in 10 μ. Cytoplasm with numerous, small chromatophores and a central nucleus.

Length of apical axis : 91 to 107 μ.

Length of pervalvar axis : 160 to 415μ.

Distribution : Island of Socotra, Ceylon and Palk Bay (Mandapam).

Since the first record of *Stictocyclus appendiculatus* and *Cerataulus thermalis* var. *sinensis* forma *ceylonica*, they have been fairly common in March-April in Palk Bay and the two species generally occur during the same period. Until then they do not appear to have belonged to an autochthonous breeding stock of this area. It may be mentioned here that Mann (1925) has recorded *Stictocyclus* from Philippines. According to Sewell (1937) during the north-east monsoon there is a strong flow of water from the Pacific to the Indian Ocean through the Straits of Malacca into the Andaman Sea and out into the Bay of Bengal. Since a certain portion of the flora that develop in a locality when the conditions become favourable may sometimes be introduced by currents, it is logical to believe that *Stictocyclus* was carried into the present locality from the Pacific, though how exactly it happened remains a matter for conjecture. In this connection the classical example of *Biddulphia sinensis* Greville may be mentioned. Lebour (1930) remarks about the distribution of *B. sinensis*, that it is an Indo-Pacific form which suddenly made its appearance in 1903 in Danish waters in the North Sea, and later in the Irish Sea and English Channel and that Ostenfeld who has investigated its distribution supposes that it was brought by some ship to the mouth of the Elbe, where finding a suitable breeding place, it reproduced freely and was carried by currents north and north-east. At Plymouth it first appeared in October 1909 and November of the same year it was noticed in Port Erin. It is felt that like *B. sinensis* the two species, *Stictocyclus appendiculatus* and *Cerataulus thermalis* var. *sinensis* f. *ceylonica* could be useful as indicators of water movement if sufficient data on the distribution of these species are available from other regions as well. Further work on these aspects is in progress.

ACKNOWLEDGEMENTS

I wish to express my thanks to Dr. S. Jones, Chief Research Officer, Central Marine Fisheries Research Station, Mandapam Camp, for encouragement. I am

grateful to Dr R. Raghu Prasad, for bringing the above diatoms to my notice and also for going through the manuscript and offering helpful suggestions and to Dr. R. Subrahmanyan. for help in the identification. I am also thankful to Shri K. G. Nambiar for taking the photographs.

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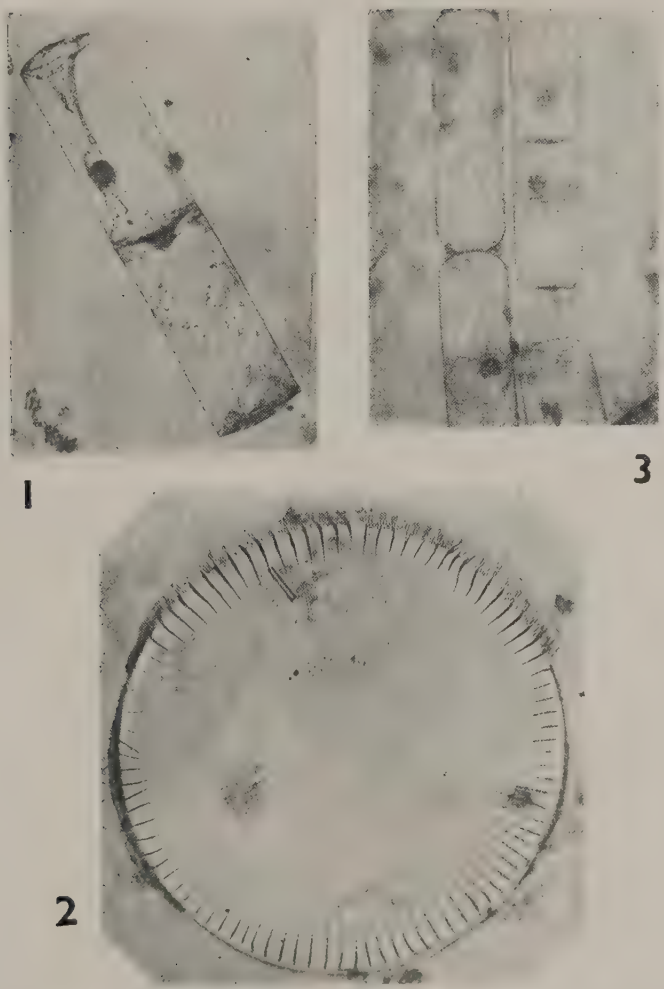

FIG. 1. *Stictocyclus appendiculatus* (Grunow) Hustedt., two cells, ×100. 2. *S. appendiculatus*, valve surface, × 450. 3. *Cerataulus thermalis* var. *sinensis* (Grun.) Forti forma *ceylonica* Skvortzow, ×150.

J. Mar. biol. Ass. India, 1960, **2** (2): 199-207

HYDROGRAPHICAL FEATURES OF THE CONTINENTAL SHELF WATERS OFF COCHIN DURING THE YEARS 1958 AND 1959

By C. P. Ramamirtham & R. Jayaraman

Central Marine Fisheries Research Sub-station, Ernakulam-5, S. India

Introduction

The hydrographical features and the seasonal variations in the physical and chemical conditions of the shelf waters off Cochin form an interesting subject of study. In this region, as well as in other areas along this coast, the influence of the south-west monsoon is very profound while that of the north-east monsoon is at best indirect. The changes in the conditions of these waters from time to time more or less reflect the changing pattern in the climatic conditions. The main circulation in the Arabian Sea results in the establishment of a surface current along this coast which reverses itself in the course of the year. This stream is southerly (i.e., towards south) when the circulation in the open part of the Arabian Sea is clockwise and northerly when the circulation is counter-clockwise. Associated with these drifts are the upwelling and sinking along this coast. The existence of these phenomena has been pointed out earlier by Sastry and Myrland (1960). In a preliminary analysis of the wind data during the period when upwelling is in evidence Jayaraman (1959) has pointed out that the prevailing winds are somewhat favourable for upwelling to take place, while Banse (1959) has regarded the prevailing current system and not the wind to be the main cause of the upwelling. It is not, however, the purpose of the present paper to discuss in detail the possible causes for upwelling or sinking along this coast, but it is intended to indicate that these various phenomena and the associated water movements could provide an explanation for the hydrographical features and their seasonal variations in the shelf waters along this coast. The interest is all the greater because Banse has shown that the demersal fisheries along this coast are fully dependent upon the prevailing hydrographic conditions.

Collection of Data

The data presented in this paper were collected during the years 1958 and 1959 from a normal section off Cochin. The collections have not been very systematic during the active period of the south-west monsoon—June to August—as the rough weather prevented going out to sea often and only when fair weather prevailed, collections were possible. More systematic collections were obtained from September onwards, although in September and October we could work only shallow stations down to 50 metres. From November onwards a number of stations were worked on this section which included a few deep stations outside the continental shelf. The inclusion of the deeper stations in the study was prompted by the need to know to what extent the deeper waters influence the conditions on the shelf.

Results and Discussions

All the data have been analysed in detail and vertical sections for the various parameters have been drawn. These vertical profiles are meant to give a better

and clearer representation of the conditions and permit drawing of broad generalizations for the purpose of characterizing the environment. These sections are shown in Figs. 1-8 and the values for dissolved oxygen given in the table below.

TABLE I

Vertical distribution of dissolved oxygen in ml/L at selected Stations off Cochin during the observational period

Depth in metres	Sept. 1958	Oct. 1958	Nov. 1958	Dec. 1958	Jan. 1959	Apr. 1959	May 1959
0	4.95	3.95	4.40	4.70	5.00	4.05	4.25
10	3.20	2.35	4.40	4.30	—	3.70	4.25
20	0.25	0.75	4.40	4.65	5.05	3.80	4.25
30	0.05	0.70	4.45	4.50	5.00	3.40	4.10
50			3.85	4.55	5.30	3.25	4.10
75			2.40	4.50	3.90	3.30	2.80
100			2.30	4.10	2.60	2.80	1.80
150			0.90	1.15	0.50	0.85	0.60
200			0.35	—	0.30	0.25	0.20
300			0.25	0.20	0.30	0.20	0.40
400			0.60	0.35	0.35	0.25	0.35
500			0.35	—	0.35	0.20	0.30

In presenting the data for purpose of discussion, we have grouped them under different categories as follows :

1. The active period of the south-west monsoon,
2. The period when upwelling is in evidence,
3. The period of sinking or downwelling,
4. The period when the environment can be considered to be fairly stable, and
5. The pre-south-west monsoon period or the transition between stable conditions and rough conditions associated with the S.W. monsoon. This type of classification, although purely arbitrary, is preferable to discussing the data month-by-month as this would present a good comparative picture of the hydrographical conditions as influenced by these various phenomena.

1. *The active period of the South-West monsoon*

The months June and July and the earlier half of August can be considered to be the active period of the south-west monsoon in the area under investigation. From the available data there is an indication that the temperature and salinity both show a tendency to decrease from the high summer values of the waters.

2. *The period of upwelling*

From the middle of August the typical changes in the hydrographical conditions associated with upwelling are in evidence. A thin layer of about 10 metres from surface downwards is characterized by very low salinity, but below this low salinity layer, there is a very sharp increase in salinity and decrease in temperature. In the month of August it was possible to work only two stations, one a relatively shallow station of depth 25 metres (St. I) and the second (St. II) which is deeper and

more offshore, the depth being 50 metres. The main characteristics at these two stations are indicated by the values given below.

	Surface		10 *metres*		20 *metres*	
	St. I	St. II	St. I	St. II	St. I	St. II
Temperature °C	26.12	26.65	24.01	26.43	23.84	24.25
Salinity $^{o}/_{oo}$	33.14	32.78	35.03	33.19	35.04	35.03
Dissolved Oxygen ml/L	6.10	5.00	1.90	5.35	0.90	1.65

It is clear from this set of values that the water at 20 metres level in the deeper station and that at 10 metre level in the shallower station has more or less the same characteristics. There is a clear indication that upwelling has commenced in this region by about the middle of August.

From the marked lowering of the surface temperature it appears that the upwelling has influenced the surface layers also ; but the influence in the salinity does not appear to be so marked. (See Figs. 1 & 5). It is probably because the influx of fresh water continues to dominate in the region. The freshets that pour into the backwaters and thence into the sea seem to extend at the surface as a tongue of low salinity water for a considerable distance from the coast. It may be seen that by the end of September ' upwelling ' seems to have been well established along this coast and the waters that have occupied the shelf have almost all the characteristics of a typical upwelled water. The following are the main features.

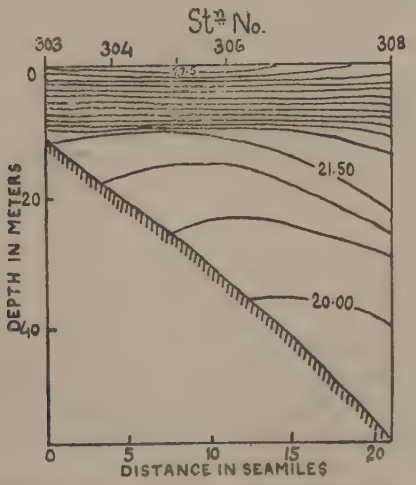

Fig. 1. Vertical distribution of temperature during upwelling—Contour Interval 0.5° C.

The temperature discontinuity seems to commence almost right from the surface. The thermal gradient is very sharp below 20 metres and except for a thin layer of 10 metres at the top, the entire shelf is pervaded by cold (below 22°C), highly saline and very poorly oxygenated water. The dissolved oxygen content is less than 0.5 ml/L below 10 metres and in some instances values as low as 0.2-0.1 ml/L

are recorded. The surface layer is well oxygenated due to the stirring action of the prevailing winds, but this oxygen-rich layer stops short of 10 metres because the forces leading to upwelling appear to be fairly strong pushing up the dense, oxygen-poor waters. It could be seen from the data that these conditions persist till about the middle of October (Fig. 1).

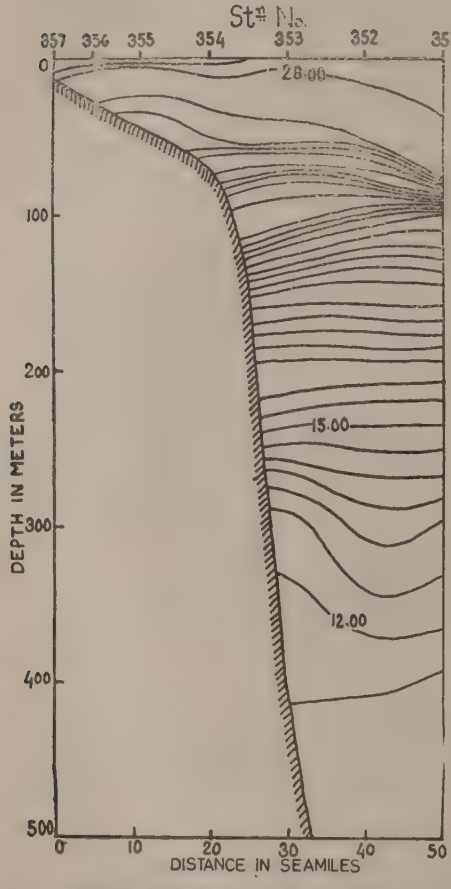

Fig. 2. Vertical distribution of temperature in the transition period between upwelling and sinking —Contour Interval 0.5°C.

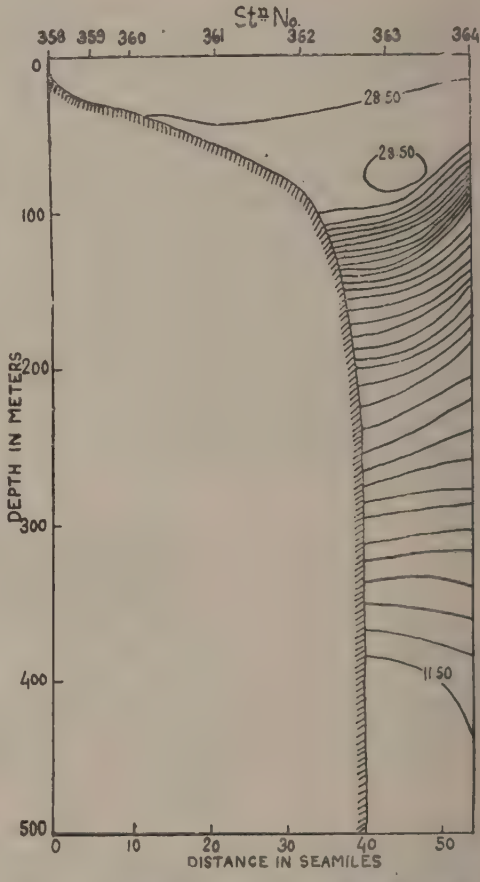

Fig. 3. Vertical distribution of temperature during the sinking period - Contour interval 0.5°C.

3. *The period of sinking or 'downwelling'*

By the end of October, the upwelling appears to have practically disappeared. The temperatures of the different layers have shown a definite increase. There is an increase of nearly 3°C in the surface temperature while at the sub-surface levels the increase has been between 5° and 7°C. The thermal discontinuity at the shallow levels has practically disappeared in the waters on the shelf by November and the entire water column down to 50 metres has become typically isothermal.

Thermocline is detectable only in the deeper waters at the edge of the shelf and beyond at about 75-100 meters. (See Fig. 2)

The entire water on the shelf has become highly saline by this time. The reasons are two-fold : firstly, upwelling has forced the highly saline waters right up to the surface and secondly, the fresh water influx has practically ceased. In the deeper waters a feebly developed salinity maximum is observed within the layer of temperature discontinuity. (Fig. 6)

It is inferred from an examination of the slope of the isotherms that there is considerable reduction in the strength of the southerly drift. This is probably a prelude to the reversal of the current which usually occurs at this time of the year.

With regard to dissolved oxygen, it may be stated that the oxygen-poor layer has tended to migrate downwards and by the end of November, a column of about 50 metres or even more on the entire shelf is saturated to the extent of 75-80%.

The conditions during the month of December are much more clearly associated with the phenomenon of sinking or ' downwelling '. The thickness of the isothermal layer with the characteristic high temperature of 28°—28.5°C has increased considerably. The thermocline in the deeper waters is detectable at 100-120 metres and is seen to be very sharp. (Fig. 3)

A notable feature of the shelf waters during this period is that the salinity is low and the vertical distribution is more or less uniform all along the shelf. During December the salinity of the shelf waters varied only between 33‰ and 34‰ and during January between 32‰ and 33‰. Just outside the shelf there is a sudden increase in salinity. A well defined salinity maximum—35.8—36.0‰ is observed within a tongue of high saline water at the thermocline in the deeper waters beyond the shelf ; but this water, in view of its high density, stops short of the continental slope or may be losing its identity on the shelf. The intensity of sinking or convergence is not known with any degree of certainty. It is however possible that, associated with this convergence there is a bottom run-off down the continental slope probably similar to the phenomenon of ' Cascading ' described by Cooper and Vaux (1949).

A clear idea of the presence of sinking at this season can be gained from the slope of the isotherms. It is also seen that the northerly drift has by now gained in strength and this movement of the water is detectable down to even 100 metres as in the case of the southerly drift. (See Fig. 3)

With regard to dissolved oxygen, the shelf waters are seen to be completely well oxygenated. Beyond the shelf, oxygen-minimum was observed below 150 metres.

4. *The period of stable conditions*

This period (March & April) is characterized by a more or less complete absence of any water movement along the coast. There is a gradual warming up of the surface layers, the temperature varying between 29.5°C and 30.5°C. A fairly sharp thermocline is present at 100 metres. (Fig. 4)

The salinity has also shown a definite increase and values higher than 34.0‰ are observed in the surface waters on the shelf. (Fig. 8)

There is not much difference in the salinities of inshore and offshore waters on the shelf and also beyond. In regard to vertical distribution, there is a definite

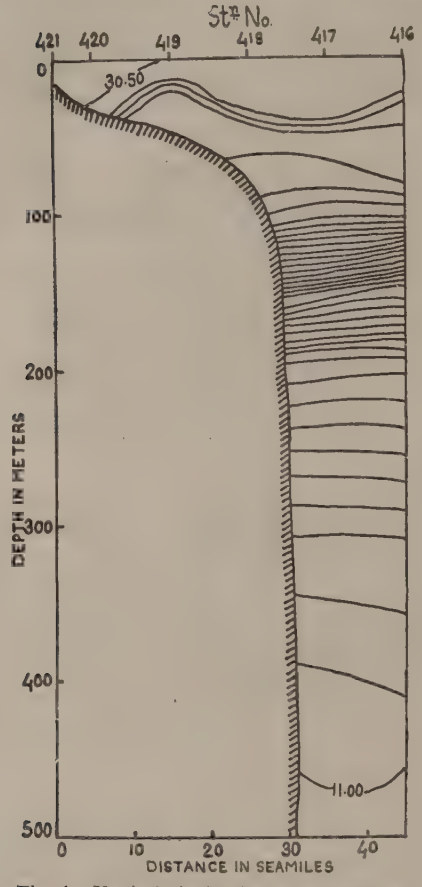

Fig. 4. Vertical distribution of temperature when stable conditions are prevailing—Contour interval 0.5°C.

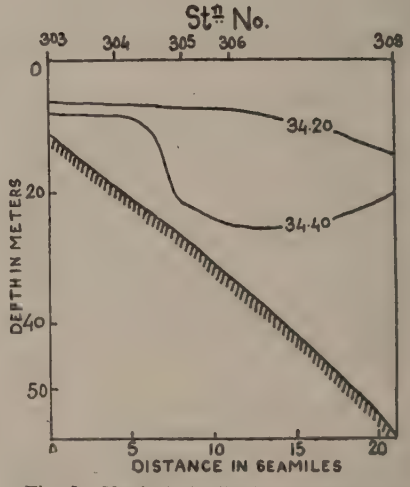

Fig. 5. Vertical distribution of salinity during upwelling.

positive gradient—i.e., increase of salinity with depth down to about 100 metres where a well-defined salinity maximum has developed. This is detectable only in the deeper waters beyond the shelf. It is clear that the waters are quite stable during this period of the year, the evidence for this is being provided by the typically horizontal character of the isotherms. (Fig. 4)

5. *Pre-south-west monsoon conditions*

During May there is a further warming up of the waters and the entire column of water on the shelf is tending to be isothermal. The surface temperature remains more or less at 31°C. The thermocline is still detectable only beyond the shelf

at depths of 75-100 metres. By the end of May the conditions become unsettled, the upper and lower sub-surface waters lose most of their individual characteristics. The salinity maximum gets dissipated by the end of this period. This latter phenomenon is observed just before the onset of the monsoon winds.

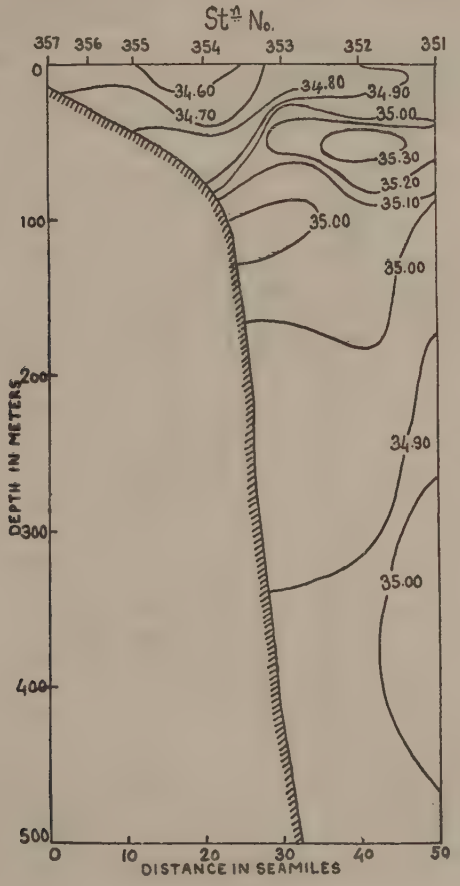

Fig. 6. Vertical distribution of salinity during transition period between upwelling and sinking.

Summary

A descriptive account of the hydrographical conditions of the waters on the continental shelf off Cochin during the years 1958 and 1959 is presented. The year is arbitrarily divided into 5 seasons depending upon the characteristic changes in the climatic as well as hydrographical conditions and these are termed as : (1) Active period of the south-west monsoon comprising mainly the months June & July and early part of August, (2) the upwelling period comprising late August,

September and October, (3) the period of sinking—November to February, (4) stable summer conditions—March and April, and (5) pre-south-west monsoon—

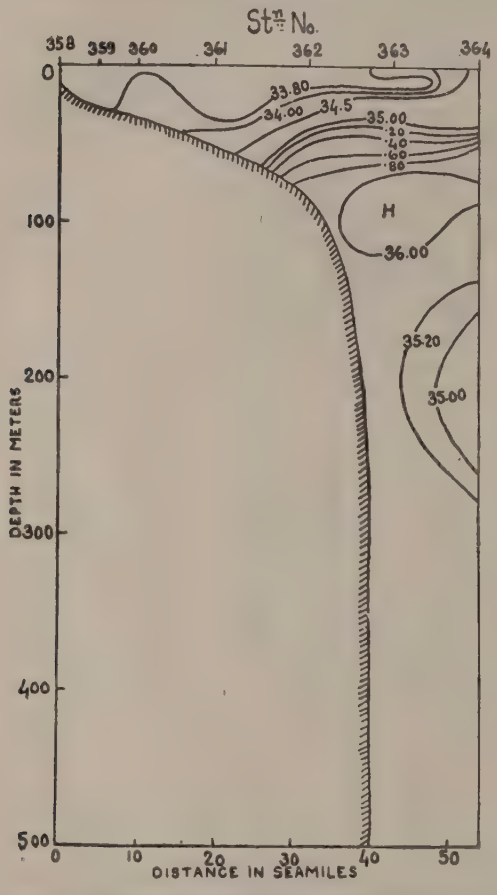

Fig. 7. Vertical distribution of salinity during sinking period.

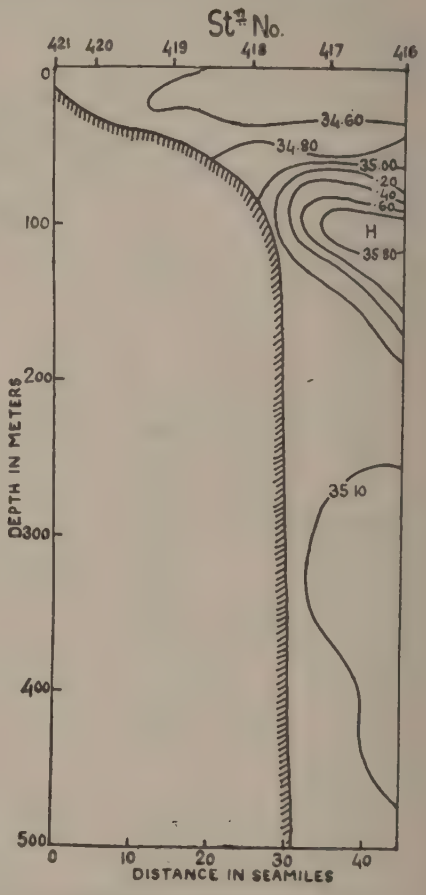

Fig. 8. Vertical distribution of salinity, when stable conditions are prevailing.

May. The factors such as temperature, salinity and oxygen content show typical seasonal variations associated with the variations in the general conditions of the environment.

Acknowledgements

Our thanks are due to Dr. S. Jones, Chief Research Officer, Central Marine Fisheries Research Station, Mandapam Camp, for his keen interest and guidance in these investigations. Thanks are also due to Dr. R. Raghu Prasad for taking

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ON A NEW GASTROCOTYLID TREMATODE, *ENGRAULICOLA FORCIPOPENIS* GEN. *ET* SP. NOV. ON WHITE-BAIT, FROM SOUTHERN INDIA

By K. C. George

Central Marine Fisheries Research Sub-station, Ernakulam

Five specimens of the monogenetic trematode described in this paper were obtained in the last quarter of 1953, at Trivandrum, from the gills of *Anchoviella bataviensis* (Hardenberg). The following description is based on the study of borax carmine stained balsam mounts of these specimens, regarded as a type series. Two of them (Fig. 1 D & E) demonstrate only the extreme shortening and bulging of the body resulting from intense contraction of these highly muscular worms, while the others are moderately extended. The reproductive organs have been chiefly studied in A, probably a somewhat younger worm, since they are less obscured by vitellaria, and there are fewer clamps than in B & C.

The general appearance is that of a 'treed' boot. The clamp-bearing haptor is developed only on one side, the other being practically inhibited. In the living worm this haptoral region is greatly extended, nearly horizontally away to the opposite side of the worm to which it belongs. In three of the specimens the haptor-frill was developed on the left side and in two (B & E) on the right side of the worm. The body proper pivots about the constricted region opposite the anterior end of the haptor and posterior to the testicular zone. Thus, while the clamp-row is fixed vertically along a gill-filament, the body has a generous arc of free movement along the cibo-respiratory current of the fish through and over the gill lamellae (the habitual postures of microcotylid and gastrocotylid worms on the gills of fishes are nicely illustrated in papers by Llewellyn—1956, 1957 *b*).

In specimens A, B & C the total length of the body axis including the bent part from near the middle of the clamp-row to the posterior tip of the haptor is respectively about 1.9, 2.9, and 2.2 mm., while the straight length from the anterior to the posterior edge of the specimen A, for instance is only 1.3 mm. The maximum width, in the ovarian zone is 0.64 mm. in A, and from 0.52 to 0.82 mm. in the others. The abruptly tapered neck region seems to be independently extensible and its length is perhaps normally between one-sixth and one-fifth of the total axial length of the worm.

The haptor is usually bent across the body axis at about a right-angle, its length in A, C & D is 0.85 mm., but in older specimen B, 1.47 mm ; or in all, very nearly half the total axial length of the worm. At its tapered tip it bears a short lappet-like protohaptor (a term proposed by Spreston & Unnithan (1960) to denote the anchor-lobe of the larval haptor) slightly extensible: the finger-like end bearing two dissimilar pairs of anchors, quite typical in shape compared with the two larger pairs in the related *Engraulicobina thrissocles* Tripathi (1959) Spreston & Unnithan, (1960). The larger anchors have long handles and lunate cusped ends of about the same length. In specimens A & B they are 29.4 μ and in C & D 25.2 μ long (Fig. 2 C). The more distal pair have very short roots, and the slightly curved claw is

directed more or less horizontally outwards and backwards and the tangential length is 12.6 μ in all the specimens, both absolutely smaller than in *Engrauliscobina thrissocles*, but of similar relative size. The distal pair of larval hooks of this species are not visible in the present species.

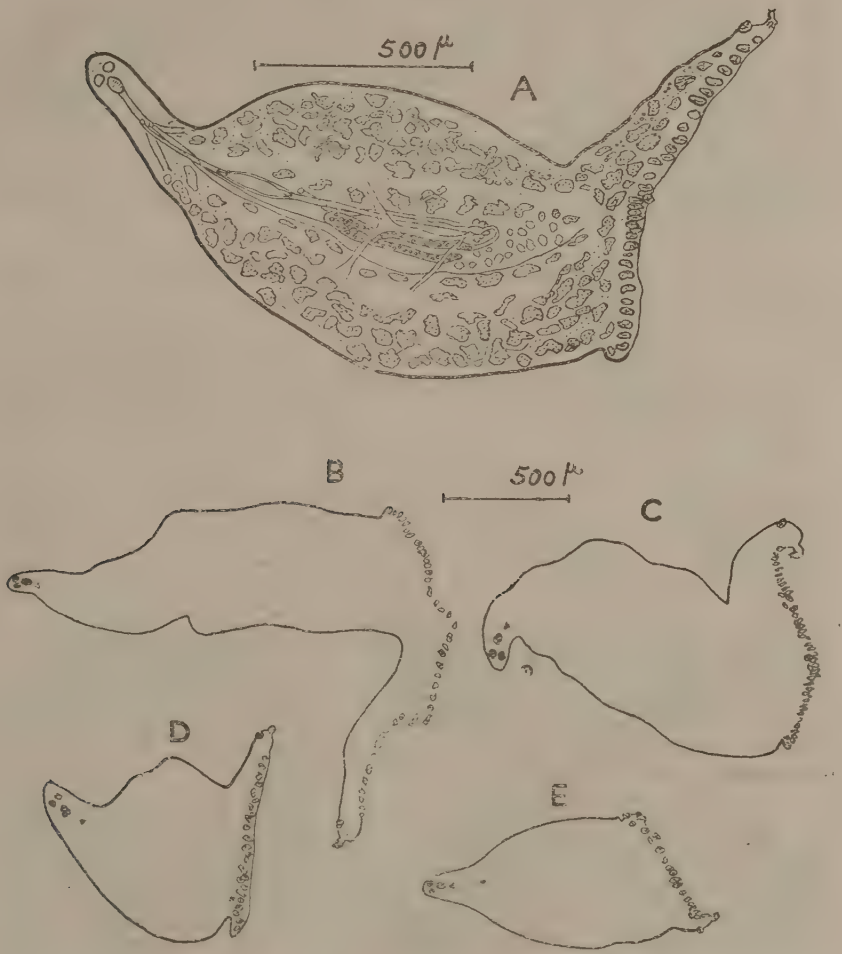

Fig. 1. A—The whole worm –type specimen, ventral view. B, C, D & E—Outline figures of 4 other specimens of the type series, ventral view.

The clamps are typically gastrocotylid in that there is a pair of oblique braces extending across the dorsal region of the clamp cavity, their outer ends articulating along the jaw rami of the dorsal jaw, often much nearer the hinge of the jaws (Fig.

2 D, E & F). They are slightly sigmoid with their inner ends rounded and posteriorly directed near the meridian, but seldom in contact, but are however very clearly articulated to the ends of the legs of the ' Y ' shaped crutch, derived from the cuticularization of the tendon arising from the short dorsal arm of the median spring. The ventral end of the median spring is no wider than its narrow arm, but there is a minutely bifurcated tip caused by the short ligaments from the edge of the ventral lip. There is a hint that there may be incipient dorsal plates in the thick capsule wall associated with the end of the spring as it passes to the crutch. There are no rib-like thickenings of the fibres in the ventral wall as in *Pricea* and *Pseudaxine* spp. Typically the clamps are twice as wide as long, increasing in size from the tip of the haptor towards the middle and then there is only a slight diminution in size to the end, where a minute clamp occurs often submarginally in all the specimens. Also in all of them there is a solitary clamp on the other side of the protohaptor ; a token of the inhibited row of that side ; analogous to the condition in the unrelated *Axinoa aberrans* (Goto) Sproston & Unnithan (1960), but homologous to the two clamps remaining in this position in *Engrauliscobina*.

The following table shows the actual sizes of the smallest (distal) and the largest (middle) clamps and the size of the solitary clamp :

TABLE 1

Ranges of clamp-size (in μ) and number in 5 specimens

Specimen	A	B	C	D	E
Smallest clamps ..	21×33	25×46	25×42	25×50.5	33.5×42
Middle clamps ..	21×50.5	33.5×63	29.5×63	33.5×84	42×63
Solitary clamp ..	33.5×37	25×37	25×42	25×33.5	30×30
Total number ...	33-1	44-1	39-1	29-1	25-1

A nearer approximation to reality of the size of these highly contractile worms would be an expression of their area which have been computed approximately from suitable micrometer measurements. There is found to be a fairly close direct relation between the areas of the worms and the number of clamps. The number of clamps may therefore be used as a measure of the size (age) in these worms and for that matter in all microcotylids and gastrocotylids ; as a relative index it is probably more reliable than length and width ranges.

The simple subterminal mouth (Fig. 2 A) lacks conspicuous glands round its lips ; it opens out over the more or less rounded oral pouches, which are aseptate and lack denticles or papillae on their rims : they vary from 37×25 μ to 50×37 μ. The pharynx is considerably larger and a highly muscular ovoid, preceded by a very short prepharynx ; its range is 50×38 μ to 59×42 μ for the two specimens A & C. The relative areas of the oral pouch and pharynx have been calculated for each of A-E (unclear in B—omitted) and the values are 50%, 77%, 61% and 50%. The oesophagus lacks diverticula and bifurcates into the two immediately branching crura at the base of the neck region, almost half its length behind the genital terminalia. Anastomoses between the crural branches are not clear due to their interstices being densely packed with vitelline follicles extending over the whole part of the body behind the genital atrium. The crura are confluent just beyond the end of the testicular zone.

The fields of the gonads are rather narrow, but the body is widest in the zone. The ovarian field begins as a rule at a distance behind the neck equal to the length of the latter. The ovary is an elongated loop with its distal limb descending, containing maturing oocytes showing clearly their zona pellucida and occupies the

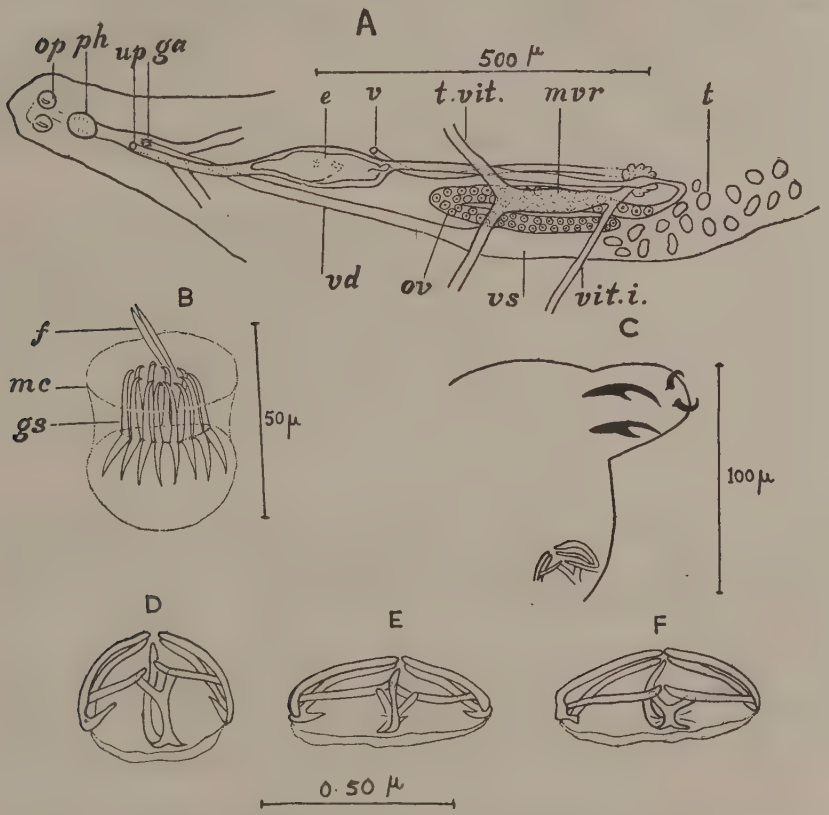

Fig. 2. A—Shows the reproductive system and anterior end of the worm—ventral view. B—Penis and genital atrium. C—The protohaptor showing the anchors and position of the solitary clamp. D—Solitary clamp, dorsal view. E—Typical clamp, ventral view. F—Typical clamp, dorsal view. *e*. Egg, *f*. Forceps-like spine at the end of the penis, *ga*. Genital atrium, *gs*. Corona of genital spines, *mc*. Membranous collar, *mvr*. Median vitelline reservoir, *op*. Oral pouch, *ov*. Ovary, *ph*. Pharynx, *t*. Testes, *t. vit*. Transverse vitelline canal, *up*. Uterine pore, *v*. Vaginal pore, *vd*. Vas deferens, *vit. i*. Vitello-intestinal canal, *vs*. Vesicula seminalis.

middle third of the body proper, even extending into the posterior third, overlapping the anterior end of the testicular zone on the left side. The testicular field is just narrow, but shorter as a rule.

The testes are in 14-18 rounded follicles arranged in two irregular rows. The vasa efferentia cannot be traced but the origin of the vas deferens is distended for at

least half its course along the right side of the ovary : this is interpreted as a functional vesicula seminalis, but is without specially muscular walls (Fig. 2 A). It opens into the round genital artium, (Fig. 2 B) surrounded by a muscular bulbous and surmounted by a corona of more or less erect spines with incurving tips and long clawed bases embedded in the atrial bulbous ejaculatorius. The penis is apparently the feebly muscular end of the vas deferens, but at its tip and emerging from the midst of the corona are two forceps-like spines. These are most highly characteristic of the species and are apparently unique in the family ; they vary from 12.6 μ to 22 μ in length (but 16.8 μ in three of the five worms). The spines of the corona are very typical of the family, particularly like those in *Gastrocotyle* and *Pseudaxine* spp. and their number is invariably 12. The diameter of the atrium is 16-18 μ but it is surrounded and enclosed by a ventrally projecting membranous and finely muscular collar : another unique feature in this species.

The transverse vitelline ducts are nearly horizontal and are confluent to form the median vitelline reservoir (Fig. 2 A). Before entering the region of the ootype, the vitelline duct gives off the vitello-intestinal canal obliquely forwards to the right, as is usual. The ootype is obscured by highly chromophilic Mehlis' gland cells, nor can the entrance of the vaginal canal be made out, but the oviduct makes a backward loop and enters the ootype-complex posteriorly. At the end of the ovary is a constriction and the oviduct has muscular walls ; this region is the oocapt or ovijector, from which eggs are ejected into the distal oviduct and thence to the fertilization chamber. The uterus arises from the left side of the ootype-complex and proceeds straight forwards to the ventral uterine pore just anterior to the atrium masculinum.

The shell of the egg is apparently elaborated during the passage up the uterus, for in specimen A while the posterior filament is clear there is no anterior filament. One of the eggs in C also has a 50 μ filament on its pointed posterior pole but the rounded anterior end is without one ; but another egg, higher in the uterus has two slightly longer polar filaments. The sizes of these eggs are respectively : 201×50 μ, 168×75 μ and 210×84 μ (exclusive of the polar filaments).

The vaginal pore was visible in only one worm (A). It is unarmed, opening on the dorsal surface about midway between the intestinal bifurcation and the transverse vitelline ducts and to the left of the median line just dorsal to the uterus. It can be traced intermittently behind the transverse vitelline ducts and in this worm can be seen just anterior to the Mehlis' gland-complex behind which it is hidden.

Relationships : When the notes on this species were drafted and the drawings made, I was unaware of *Engrauliscobina thrissocles* Tripathi (1959) Sproston & Unnithan (1960) on *Thrissocles mystax* from Puri (Bay of Bengal). It is evident that *Engraulicola forcipopenis* gen. et sp. nov. is closely related to the former, but I do not consider them congeneric mainly for the following reasons :

1. The presence in *Engraulicola* of a pair of forceps-like spines at the tip of the penis and a cylindrical sheath surmounting the atrial bulb.
2. The haptor-frill in *Engraulicola* is adherent to the body only up to the testicular zone, whereas in *Engrauliscobina* it is practically co-extensive with the gonad zone.

In genera where the haptor-frill embraces the less flexible part of the body, including the gonad zones, the pivoting of the body proper on the fixed clamp-row(s)

invariably induces a torque in the body resulting in bizarre asymmetry, transient or permanent according to the rigidity of the body wall, for example in *Thoracocotyle ovalis* Tripathi (1956) (nom. emend. 1959), and in *Vallisia* spp. In *Engrauliscobina*, there is asymmetry for the same reason, which may well be more marked in flexed and extended specimens, since the zone of pivoting involves the least flexible region ; the middle of the gonad zone. Whereas in *Engraulicola* the zone of pivoting being flexible, posterior to the thick gonad zone, no marked somatic distortion occurs and even the most extended and flexed worms would retain an approximate symmetry of the body proper.

It is noteworthy that the token clamps in both the genera on Engraulidae are about as wide as long, since they are not subjected to the exigencies of crowding ; which has opposite effects in the two genera, the one with clamps much longer than wide and in the new genus about twice as wide as long.

The forceps-like spines on the penis may be analogous to the extremely long vagina-dilators of the atrium musculinum (as interpreted by Unnithan 1960) in *Heterapta heterapta* Unnithan and *H. chorinemi* (Tripathi) Unnithan, the multi-spined penis in this genus being protrusible between them. The only parallel (probably an homology) is the hitherto unsubstantiated observation of the original authors of *Pseudaxine trachuri* Par. & Per 1890 ; a corona of slender spines was shown on the penis head, protrusible through a corona of very short spines round the inner rim of a muscular atrium (see Fig. 109 *c* in Sproston 1946).

Generic diagnosis of *Engraulicola* gen. n. : Gastrocotylidae, in which there is a unilateral haptor-frill and a single token clamp on the inhibited side ; the protohaptor persists as a finger-like lobe bearing two dissimilar pairs of anchors, one with a root as long as its lunate end and the other with vestigial roots. Clamps are without conspicuous plates in dorsal wall or ribs ventrally ; wider than long. Haptor-frill barely embraces the end of the testicular zone ; hence the zone of pivoting on the fixed clamp-row is in a flexible region of the body and the symmetry of the latter is not disturbed. Testes in irregular rows of rounded follicles. Vas deferens with a proximal dilatation ; penis weak but carrying a pair of forceps-like spines round the muscular atrial bulb, itself surmounted by a delicate cylindrical sheath projecting centrally beyond the atrial spines. Dorsal vagina unarmed, slightly to the left of the median line, not far in front of the ovary, its duct leading directly to the ootype-complex. Oral pouches aseptate and about half the size of the pharynx. Eggs with filaments, shorter than the egg, at each pole. Parasites on the gills of *Anchoviella* species. Monotypic with *Engraulicola forcipopenis* sp. nov. on *A. bataviensis* (Hardenberg), from Trivandrum (Arabian sea).

Phylogenetically this is a particularly interesting genus since all other Gastrocotylidae, except *Engrauliscobina* (also on Engraulidae) occur on higher Perciformes : Carangidae, Scomberomoridae, etc. This apparent migration of gastrocotylid worms to hosts on the lower branches of the phylogenetic tree of fishes, has been suggested by Sproston (1960) as predator-prey transfer : the dense shoals of the clupeoid prey being favourably exposed to infection by ancestors of these gastrocotylids infecting the predators, in the same watermass, practically simultaneously with the shoals of Anchovies or white-baits (which increase the probability of infection by the rapid reusage of the water by the hinder members of the shoal). The problem now emerges as to the independent transfer of ancestors of these two genera on clupeoids, or whether one has evolved from the other, since *Thrissocles* spp. do occupy the same watermasses, from time to time, as do *Anchoviella* spp.,

though they are not now commonly caught together in large quantities in Indian coastal waters.

Summary

Engraulicola forcipopenis gen. *et* sp. nov., on the gills of *Anchoviella bataviensis* (Hardenberg) from Trivandrum is described and figured : a highly contractile gastrocotylid, its wide body dark with vitellaria and dense melanotic deposits. One side of the haptor is inhibited leaving a solitary token clamp at the side of the terminal ' protohaptor ' bearing two dissimilar pairs of anchors ; the haptor-frill is bent almost at right-angles across the end of the body, extending laterally on the opposite side. A narrow neck carries aseptate oral pouches and a pharynx twice their size, also the bulbous atrium musculinum with its corona of 12 nearly erect spines, through which is protruded the head of the small penis with its unique pair of pointed forceps-like spines ; the whole atrium being surmounted by a membranous collar projecting ventrally beyond it. A dorsal unarmed vagina opens nearer the ovary and leads direct to the ootype-complex ; eggs with bipolar filaments.

Asymmetry of the body is avoided by the pivoting axis of the same in relation to the fixed clamp-row lying in a flexible zone behind the testes, unlike in the related *Engrauliscobina thrissocles* where asymmetry exists due to the pivoting axis being in the least flexible part of the body embracing the gonad zone.

While in *Engrauliscobina* the clamps are much longer than wide, the reverse is the effect of their crowding in *Engraulicola*. Both genera are exceptional among gastrocotylidae in occurring on clupeoid fishes and the host-parasite phylogenetic problems are referred to.

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RATE OF GROWTH OF *BANKIA INDICA* NAIR, A SHIPWORM FROM THE MADRAS COAST

By N. Balakrishnan Nair

University of Madras, Extension, Madurai

Even though sixty papers have been published on the different aspects of marine boring organisms of India, very little information is available on the rate of growth of Indian shipworms which cause very serious damage to submerged timber all along the sea coasts. The growth of these specialised, wood boring bivalves is directly related to the damage they effect on timber since each shipworm during its lifetime destroys a column of wood of the same dimension as its largest size and it was therefore interesting to make a study of the rate of growth of a local shipworm *Bankia indica*. In the present study four aspects have been taken into consideration namely growth in length of the body, (i.e. increase in length of the burrow) increase in weight of the body, increase in the number of ridges of the shell and growth in length and breadth of the shell valves.

By submerging conditioned test timbers of red-cedar (*Cedrela toona*) off San Thome, Madras, it was possible to obtain a set of shipworms whose age could be estimated with a considerable degree of accuracy. These test timbers having been placed in the sea during the height of the breeding season (June-August) (when the water was swarming with larvae) may safely be assumed to have been attacked within a few days of submergence. Since this teredine *Bankia indica* has been found to subsist mainly on the wood into which it bores Nair (1955) and since its growth in length is proportional to the length of the burrow, the latter may be related to the period of tenancy and therefore the age of the animal. Several test panels of red-cedar were suspended (in the sea during June in sites where the sea water was swarming with larvae.) Each month one of the panels was lifted out and the settled borers were studied. The longest specimens were selected since they represent those which were first to enter the wood after it was placed in water, as was done by Miller (1922). In the normal living state each shipworm fills its burrow the length of which therefore, may be treated as the length of the animal and carefully measured throughout its course. The average of the lengths of these would give the average length attained by the earliest settlers during the month in question. In the second month another of the panels was removed and the longest burrows were measured, the average of these will give the average length of *Bankia* settled approximately two months ago. In this way the borers from eight panels were studied from June 18, 1954 to January 23, 1955. The weights of the animals were recorded after drying them between folds of filter paper. The linear dimensions of the shell were measured with a pair of vernier callipers, the very small ones were measured with a micrometer. The dental ridges on the anterior lobe of the shell were counted under a lens. The error in the calculation of the ridges that may arise due to erosion of the ridges by friction or by overgrowth of the shelly material over the ridges are unavoidable and hence has been dealt with as 'negligible for practical purposes' as suggested by Miller (1922). Since by the seventh month the test panels became so riddled by the borers as to become fragile and brittle, observations were limited to a period of 219 days from the time of immersion of the panels.

TABLE 1

Showing measurements of *Bankia indica* of maximum size groups in respective months from test blocks of *Cedrela toona* submerged in the open sea on 18 June 1954.

	July 5	July 20	August 25	September 21	October 21	November 30	December 26	January 23
Approximate age in days	17	32	68	95	125	165	191	219
Mean length of the burrow in mm.	9	23	142	224	257	274	290	302
Mean wet weight of the animal in gm.	0.2	0.5	0.96	2.12	3.29	3.76	4.56	5.13
Mean height of the shell in mm.	1.77	3.9	7.58	8.09	9.33	9.63	9.88	9.96
Mean length of the shell in mm.	1.78	3.54	6.65	7.64	9.48	9.76	10.12	10.4
Mean number of ridges	16	25	44	55	63	68	71	71
Number of animals examined	20	15	19	21	12	7	5	3
Temperature °C.	28.1	28.4	29.1	28.5	28.6	27.1	26.3	26.4
Salinity ‰	33.3	33.4	33.7	32.8	26.5	27.4	28.5	30.6

The data obtained from the examination of individuals of maximum size groups during each month were averaged as for that month and the figures 1 to 4 show the different readings obtained during the period of the experiment. The data presented in Table I and illustrated in Fig. 1 show the growth in length of the animal, Fig. 2 growth in size of the shell, Fig. 3 increase in the number of ridges and Fig. 4 increase in weight of the animal. From these figures it will be clear that growth is very rapid in the first 90 days and thereafter becomes slackened and the trend indicates the rate of growth becoming negligible at the end of 219 days. This suggests that the growth in length is retarded by the depletion of the woody material in the panel due to overcrowding. It is possible that if larger volumes of wood had been offered the increase in length would have continued for a longer period than seven months. In the same way, the size of the shell, and the number of ridges, which depends on the size, may have slackened in their growth in a way related to the retardation in growth in length. In the case of the figure 4 unlike the others the plotted points suggest an almost straight line fit indicating that the increase in weight is directly proportional to time. Therefore, it may be inferred further that growth in weight of the animal after it has ceased to grow in length might probably be due to the accretion of calcareous matter and growth in bulk of the shell which continues unabated throughout the period. This is probably due to the absorption of mineral matter from the sea being independent of the volume of wood and therefore directly proportional to the age of the animal. Within the limits of the experiment, i.e., using $5' \times 3\frac{1}{2}'' \times 4''$ panels of red-cedar, the rate of growth

up to a period of 90 days seems to be a correct representation as growth is not affected by such factors as over-crowding and scarcity of wood during the time.

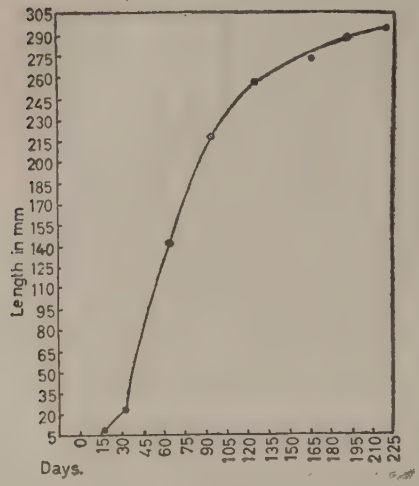

FIG. 1. Curve showing growth in length of the body.

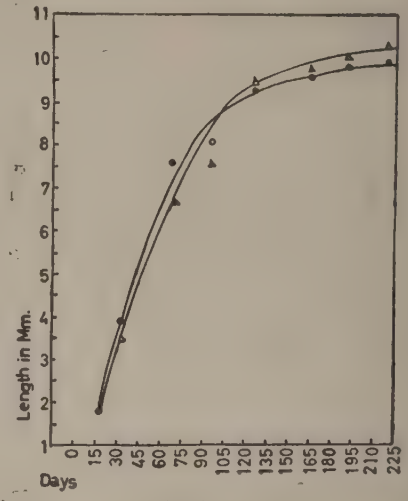

FIG. 2. Curves showing growth of the shell.
● Height of shell
▲ Length of shell.

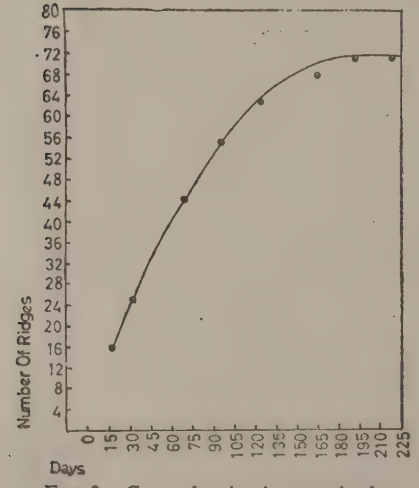

FIG. 3. Curve showing increase in the number of ridges of the shell.

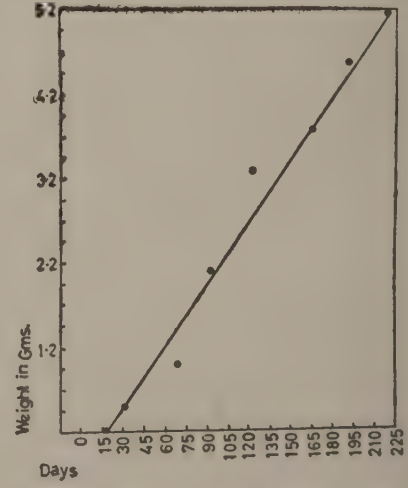

FIG. 4. Graph showing increase in weight of the body.

A comparison of the rate of growth of this tropical borer with that of allied forms elsewhere will be of interest. *Teredo navalis* grows to a length of 0.35 to

0.5 mm. in 18 days, 8 to 10 mm. in 33 days, 100 to 120 mm. in 72 days and takes 1 year to reach a length of 250 to 400 mm. in Woods Hole (Grave 1928). In *Bankia gouldi* from North Carolina, the growth as reported by Sigerfoos (1908) is 3 mm. in 12 days, 6 mm. in 16 days, 11 mm. in 20 days, 63 mm. in 30 days and 100 mm. in 36 days. This represents a higher growth rate than what Richards and Clapp (1944) reported for the same species from Florida waters while in the present form the growth in length was 9 mm. in 17 days, 23 mm. in 32 days, 142 mm. in 68 days, 224 mm. in 95 days, 257 mm. in 125 days, 274 mm. in 165 days, 290 mm. in 191 days and 302 mm. in 219 days. Miller (1922) observed in *Teredo navalis* that the rate of growth as measured by the addition of ridges is extremely rapid during the first month (9.3) after which it stops suddenly remaining nearly constant during the next 2 months (3.8-3.6) followed by a further decrease during the fourth month (2.6) and suggested that the decrease is explainable due either to the lowering of temperature or due to the effects of crowding limiting further growth. The present study shows that the growth based on the additions of ridges was rapid in the first 2 months (25 and 19) which was followed by a sharp fall (11) even though the addition of ridges continued until the 6th month after which it remained constant. Kofoid and Miller (1927) found in *Bankia setacea* an average rate of boring of about 4.7 cm. per month in the Pacific area which is slightly higher than the values obtained during the present study (4.3 cm. per month). On the other hand in Friday harbour Johnson & Miller (1935) reported that the largest specimen of *Bankia setacea* measured 3.9 cm. long from a block which had been exposed for 4 months from September to January. The average length of 10 longest specimens was only 2.54 cm. with a rate of growth of about 1 cm. per month. These observations indicate that the rate of boring of the different species in different regions shows great variations. Ralph and Hurley (1952) obtained an ordinary growth curve for *Bankia australis* based on measurements of burrow lengths of the longest burrow in the block for each month. The curve however showed a deceleration of growth rate in September and November (winter and spring) as noted by Isham *et al* (1951) who have interpreted this as consequent from overcrowding even though for *B. australis* the deviation of the curve was attributed to individual variations. Johnson *et al* (1936) noted a diameter of 3/16 of an inch at the end of 3 months growth of 3 Australian species.

In the present study there was no perceivable correlation between the rate of growth and hydrographic conditions, such as temperature and salinity of the surrounding waters (Table 1) even though in Malpeque Bay, Needler and Needler (1940) noted maximum growth rate in shipworms coinciding with the period of highest temperature. Salinity was not associated with the seasonal cycle in growth. Isham *et al* (1951) also noticed rapid growth in *Teredo pedicellata* during midsummer at Miami and in panels exposed for more than 2 months the summer growth rate was reduced as a result of overcrowding. In the present study any retardation in growth rate due to overcrowding was noticeable only after a period of about 3 months. It will be seen from the above that there is considerable variation in the rate of growth of the different species of shipworms and even of the same species at different localities and exact comparisons of the rate of growth are very difficult due to lack of sufficient data regarding the factors responsible for the variation of growth of shipworms in the different types of timbers and with age and season.

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FLORA OF THE PEARL BEDS OFF TUTICORIN*

By R. Prasanna Varma

Central Marine Fisheries Research Station, Mandapam Camp

This account deals with the algae collected during a survey of the pearl and chank beds off Tuticorin during December 1958 to May 1959, conducted by Dr. F. Baschieri-Salvadori, F.A.O. Underwater Expert, in collaboration with Mr. K. Nagappan Nayar of the Central Marine Fisheries Research Institute and Mr. Isaac Rajendran of Madras State Fisheries, to whom the author is grateful for the algal collections. In addition, during the above period pearl fishery was in progress (March to May) and the algae brought by divers along with oysters were also studied by the author.

Practically no information is available on the deep water algae of the Indian coast except a few records published by Boergesen (1937*a*, 1937*b* and 1938). The present account gives a fair picture of the flora of these pearl beds (Paars) in relation to substratum and depth. Though all the Paars had some form of algal vegetation, of the 33 Paars examined, only 11 had luxuriant growth of algae. Broadly, these Paars are grouped into four zones based on the dominant community ; i.e., dominated by red algae as in Zone I, dominated by green algae as in Zone II, a balanced vegetation without any particular group dominating as in Zone III, and dominated by brown algae as in Zone IV. It may be mentioned here that Zone III merges with Zone IV and the dominance by brown algae in Zone IV is not very distinct. Table 1 gives the details of Paars, substratum and algal growth ; Text-Fig. 1 indicates the Paars studied.

A more critical consideration of these zones reveals that Zone IV has the maximum luxuriance of vegetation, with a complex community attaining almost a good balance between the red and brown algae, though the collections from the luxuriant beds of Karai Karuwal, Velangu Karuwal and Trichendur Poontottam Paars indicate the dominance of brown algae, particularly Sargassums. Among the red algae, the more striking ones are *Gracilaria edulis* (Gmel.) Silva, *Hypnea valentiae* (Turn.) Mont., and *Polysiphonia tuticorinensis* Boergs. The next best is Zone I, having an excellent growth of *Avarainvillea erecta* (Barkel.) Gepp, *Bryopsis corymbosa* J. Ag., *Caulerpa fergusonii* Murr., *C. peltata* Lamx., *C. taxifolia* (Vahl) Ag., *Halimeda opuntia* (L.) Lamx., and *H. tuna* (Ellis & Sol.) Lamx. Though the two Paars of this zone have excellent growth of green algae, the dominant community consists of red weeds. In Zones I and II, crustose coralline algae and epiphytic algae are very common. In these categories, notable ones are *Acrochaetium* spp., *Climacosphenia moniligera* Ehrenberg, *Griffithsia* sp., *Leveillea jungermannioides* (Mart. et Herv.) Harv., *Licmophora abbreviata* Ag., *Lithophyllum* sp., *Lithothamnium fruticulosum* (Kütz.) Foslie, *Melobesia pustulata* Lamx., *Polysiphonia platycarpa* Boergs., and *Sphacelaria furcigera* Kütz.

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TABLE 1

Zone	Number.*	Name of Paar	Depth in Meter	Substratum	Algal growth
I	1	Devi Paar	12-15	Flat rock with very little sand.	excellent
	2	Pernandu Paar	12-14	do.	do.
	3	Vaippar Periya Paar	12-14	Thick sand over muddy bed with broken shells.	poor
	4	Cruxian Paar	12-18	Rocky covered with sand and plenty of shells.	fair
	5	Vantivu Arupagam Paar	10-12	Rocky and coral bed covered with sand.	excellent
	6	Nagara Paar	13-14	Rocky bed with very little sand.	fair
	7	Uti Paar	14-17	Flat rock with very little sand.	fair
	8	Uduruvi Paar	14-17	do.	poor
II	9	Kilati Paar	13-14	do.	fair
	10	Attuvai Arupagam Paar	14	Sandy bed with very few rocks.	poor
	11	Pattarai Paar	14-18	Flat rock with little sand and broken shells.	poor
	12	Pasi Paar	14-18	Flat rock covered with sand.	fair
	13	Attonbadu Paar	16-18	Sandy bed with broken shells.	good
	14	Tolayiram Paar	15-21	Rocky with patches of sand.	excellent
	15	Kutadiar Paar	15	Flat rock with very little sand.	fair
	16	Par Kudanjan Paar	14-17	Rocky with very little sand spread over.	poor
	17	Nenjurichan Paar	15	do.	do.
	18	Mela Onbadu Paar	14-16	do.	good
	19	Vada Onbadu Paar	16-17	do.	do.
	20	Saith Onbadu Paar	14-16	do.	excellent
III	21	Puli Pundu Paar	15-18	Rocky with patches of sand-covered areas.	good
	22	Pinnakayal Sultan Paar	17	Sandy with broken shells.	poor
	23	Sankuraiya Pattu Paar	20	do.	do.
	24	Rajavukku Sippi Soticha Paar	16-18	Flat rock with crevices and little sand.	fair
	25	Kudamuttu Paar	14-16	Flat rock with little to heavy covering of sand.	fair
	26	Saith Kudamuttu Paar	14-16	Flat rock with crevices.	good
	27	Kadian Paar	14-16	Fissured rock with little sand.	poor
	28	Kanava Paar	14-16	Sandy bed with broken shells.	poor
	29	Naduvu Malai Piditta Paar	16-18	Sand covered rocky bed.	poor
IV	30	North Karuwal Paar	16-18	Rocky with little sand.	excellent
	31	Karai Karuwal Paar	16-18	do.	do.
	32	Velangu Karuwal Paar	16-18	do.	do.
	33	Trichendur Poontottam Paar	14-18	Fissured rock with sand.	do.

*This number corresponds with the numbering of Paars in text figure 1.

The largest single Paar in the groups examined is in Zone II—Tolayiram Paar—and has a vegetation which could be considered to represent the typical pearl bed flora. The collections from this Paar showed most of the species collected from the rest of the 32 Paars, though the green algae dominated. Zone III, as indicated earlier, had a balanced vegetation. Here, the remarkable feature is the absence of most of the foliose forms ; even Dictyotas were very few. Further, the beds in this

zone were rather poor and most of the algae collected were found growing on the oyster shells.

Though much emphasis cannot be given to size in relation to depth, it is worth mentioning that in general, the deep water algae are more delicate and most of them

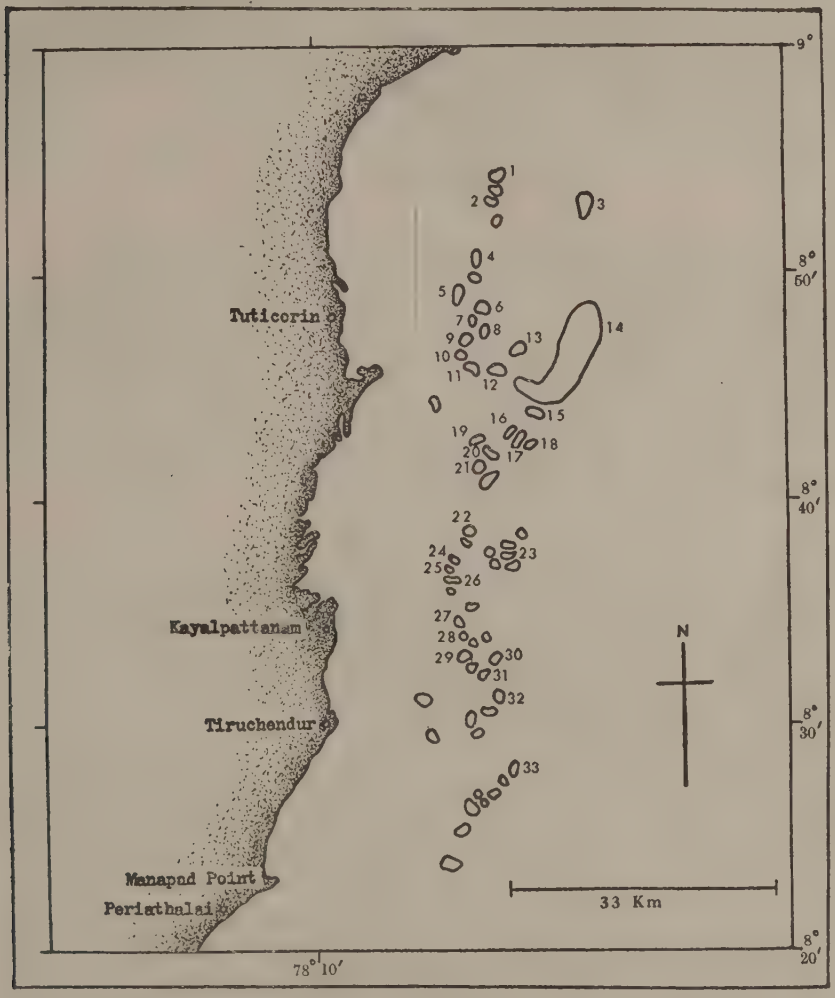

Fig. 1.

are small-sized species. The probable exceptions seen in this study are *Spathoglossum asperum* and *Polysiphonia tuticorinense*. Even in the case of Sargassums and Padinas, the plants are very much reduced and in the latter, calcification is also very little.

From the list of algae given in this account, it will be clear that the algae of the pearl beds are mostly of the types found in coral beds or rocky regions of the Indian coast, irrespective of depth. In other words, there seems to be no selectivity for algae with regard to depth. But, in the case of green algae, the majority of forms inhabiting the deep waters belong to the Siphonales. Very surprisingly, blue-green algae were totally absent in the above collections ; only twice the author got a few filaments of *Lyngbya* sp., entangled among *Hypnea valentiae*. Further, the dominance of green algae depends on the presence of sand or mud on the Paars ; very favourable growth of Caulerpas, Padinas and Halimedas were seen on those Paars which are covered with sand. Same is the case with Gracilarias and Hypneas.

List of algae in the four zones

ZONE I :

Avrainvillea erecta (Berkel.) Gepp, *Bryopsis corymbosa* J. Ag., *Caulerpa fergusonii* Murr., *C. peltata* Lamx., *C. taxifolia* (Vahl) Ag., *Climacosphenia moniligera* Ehrenberg, *Halimeda opuntia* (L.) Lamx., *H. tuna* (Ellis & Sol.) Lamx., *Licmophora abbreviata* Ag., *Dictyota atomaria* Hauck, *D. bartayresiana* Lamx., *Padina commersonii* Bory, *Spathoglossum asperum* J. Ag., *Acanthophora spicifera* (Vahl) Boergs., *Herposiphonia insidiosa* (Grev.) Falkenb., *Heterosiphonia stuposa* (J. Ag.) De-Toni, *Hypnea valentiae* (Turn.) Mont., *Jania rubens* (L.) Lamx., *Laurencia obtusa* (Huds.) Lamx., *L. papillosa* (Forssk.) Grev., *Leveillea jungermannioides* (Mart. *et* Herv.) Harv., *Lithophyllum* spp., *Lithothamnium fruticulosum* (Kütz.) Foslie, *Melobesia pustulata* Lamx., *Polysiphonia platycarpa* Boergs., *P. tuticorinense* Boergs.

ZONE II :

Avrainvillea erecta (Berkel.) Gepp., *Caulerpa cupressoides* (Vahl) Ag., *C. fergusonii* Murr., *C. peltata* Lamx., *C. taxifolia* (Vahl) Ag., *Cladophora utriculosa* Kütz., *Climacosphenia moniligera* Ehrenberg, *Codium coronatum* Setch., *Halimeda tuna* (Ell. *et* Sol.) Lamx., var. *platydisca* (Decsne.) Barton, *Licmophora abbreviata* Ag., *Microdictyon tenuius* (Ag.) Decsne., *Neomeris annulata* Dickie, *Struvea tuticorinensis* Boergs., *Ulva lactuca* L., *Dictyopteris australis* Sond., *D. delicatula* Lamx., *Dictyota bartayresiana* Lamx., *D. dichotoma* (Huds.) Lamx., *D. maxima* Zan., *Ectocarpus breviarticulatus* J. Ag., *Hormophysa triquetra* (L.) Kütz., *Padina commersonii* Bory, *P. gymnospora* (Kütz.) Vick., *Sargassum wightii* (Grev. & Mscr.) Ag., *Spathoglossum asperum* J. Ag., *Sphacelaria tribuloides* Menegh., *Acanthophora spicifera* (Vahl) Boergs., *Acrochaetium canarense* Boergs., *A. tuticorinense* Boergs., *Amphiroa fragilissima* (L.) Lamx., *Botryocladia leptopoda* (J. Ag.) Kylin, *Ceramium rubrum* (Huds.) Ag., *C. transversale* Collins et Herv., *Champia indica* Boergs., *C. parvula* (Ag.) Harv., *Chondria transversalis* Boergs., *Claudea multifida* Harv., *Galaxaura oblongata* (Ell. et Sol.) Lamx., *Gelidiopsis variabilis* (Grev.) Schmitz, *Gracilaria edulis* (Gmel.) Silva, *Halymenia floresia* (Clem.) Ag., *Heterosiphonia muelleri* (Sond.) De-Toni, *H. stuposa* (J. Ag.) De-Toni, *Hypnea musciformis* (Wulf.) Lamx., *H. pannosa* J. Ag., *H. valentiae* (Turn.) Mont., *Laurencia obtusa* (Huds.) Lamx., *L. paniculata* J. Ag., *Lophocladia lallemandi* (Mont.) Schmitz, *L. trichoclados* (Mett. *et* Ag.) Schmitz, *Martensia fragilis* Harv., *Melobesia pustulata* Lamx., *Neurymenia fraxinifolia* (Mert.) J. Ag., *Polysiphonia platycarpa* Boergs., *P. tuticorinensis* Boergs., *Roschera glomerulata* (Ag.) W. v B., *Sarconema filiforme* (Sond.) Kylin, *Scinaia hatei* Boergs., *Spyridia filamentosa* (Wulf.) Harv., *Vanvoorstia spectabilis* Harv.

ZONE III :

Cladophora utriculosa Kütz., *Bryopsis plumosa* (Huds.) Ag., *Halimeda opuntia* (Ell. *et* Sol.) Lamx., *Ectocarpus arabicus* Fig. *et* De-Not., *Dictyota maxima* Zan., *Champia indica* Boergs., *Galaxaura oblongata* Lamx., *Hypnea musciformis* (Wulf.) Lamx., *Jania rubens* (L.) Lamx., *Laurencia paniculata* J. Ag., *Lithothamnium fruticulosum* (Kütz.) Foslie, *Melobesia pustulata* Lamx., *Roschera glomerulata* (Ag.) W. v B., *Spyridia filamentosa* (Wulf.) Harv., *S. fusiformis* Boergs.

ZONE IV :

This Zone had the same flora as Zone II, but in addition the following algae were also collected from the Paars of this zone : *Dictyopteris muelleri* (Sond.) W. v B., *Sargassum myriocystum* J. Ag., *Champia globulifera* Boergs., *Dictyurus purpurascens* Bory, *Grateloupia lithophila* Boergs., and *Lynkiella karuvalensis* Varma. Of these, *Lynkiella karuvalensis* and *Dictyurus purpurascens* were seen ony in Karai Karuwal and Velangu Karuwal Paars.

From all the four Zones, *Halophila ovalis* (R. Br.) J. D. Hooker was collected and this member of the Hydrocharitaceae was always associated with sand covered Paars.

Detailed descriptions of some of the interesting species as well as a few doubtful genera will be published elsewhere.

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STUDIES ON THE SHRIMP *CARIDINA LAEVIS* (HELLER)

II. The Reproductive System

By R. Sridharan Pillai*

Department of Zoology, University College, Trivandrum

This paper is the second part of the series dealing with the anatomy of the freshwater shrimp *Caridina laevis*. A paper on the Digestive system has already been published (Pillai 1960).

METHODS

The morphology of the reproductive system was studied mostly by dissecting anaesthetised specimens under the stereoscopic binocular microscope. In addition to Bouin's fluid, Zenker formol, Formol saline and Carnoy's fluid were used as fixatives and Heidenhain's iron haematoxylin, Heidenhain's Azan as stains and Mallory's connective tissue stain as counter stain. Squash technique was employed for studying the chromosome number using aceto-orcein as stain-fixative (La Cour, 1941). Growth of the ovary was studied on live animals through the transparent cuticle.

External sex differentiation

The coxopodites of the pleopods get coalesced with the sternal plates in males with the result that the two appendages of the same segment originate close together. In the females they are far apart, providing space for the accommodation of eggs during spawning. In the male (Fig. 2) the exopodite of the first pair of pleopods is longer and extends to the base of the third maxilliped of the same side, while in the female (Fig. 1) it extends only upto the coxa of the third walking leg. The endopodite in the male is short, blunt, almost completely fringed with setae and runs obliquely towards the front whereas in the female it is narrow, acute, long, almost bare and directed posteriorly. While the two endopodites on either side cross each other in the female they do not even touch in male. The first pair of pleopods do not develop appendix interna in both the sexes. The second pair of pleopods in the female is similar to those behind. In the male (Fig. 3) it is markedly distinctive bearing the appendix masculina between the endopodite and the appendix interna. The appendix masculina is armed on its mesial side with two rows of short and jointed spines.

1. Male Reproductive System

Morphology of testis and vas deferens

The testis (Fig. 4) consists of two simple tubes with a precardiac connection. Its anterior part is slightly convoluted. The vas deferens, arising from the anterior one-third of the testis passes backwards, gets folded on itself and is again reflected

* Present Address : Zoological Survey of India, 34 Chittaranjan Avenue, Calcutta-12.

back. The ultimate portion is superficial and runs below the last branchiae to open out on the inner side of the last walking leg.

Histology of testis (Fig. 5)

The testis is enveloped by an outer epithelium with flattened nuclei below which is the general germinal layer. Only the cells of one side of the germinal epithelium actively form the germinal ridge. The cells of the germinal ridge have large diffuse nuclei with more than one nucleolus. In the precardiac portion of the testis, this ridge almost fills the cavity of the testis. It is here that the peak of transformation of spermatocytes into spermatids and spermatozoa is noticed. Concurrent with the formation of the spermatocytes with large diffuse nuclei, smaller nuclei with variable shapes and indistinct cytoplasmic boundaries have also been observed to be formed inside the germinal ridge. Though the details of the spermatogenesis have not been studied, certain observations have been made about these cells, the so-called nutritive cells. Their nuceli which may be spherical, oval, elongated or irregular, are highly chromophilic and are found only in the vicinity of the primary spermatocytes. Invariably these cells are situated towards the periphery of the testicular wall, nearer to the blood that surrounds the testis and it is possible that they serve a nutritive function. There are various views regarding the origin of these cells. Earlier workers held that the nutritive cells gave rise to primary spermatocytes (Grobben, 1878 and Hermann, 1890). On the contrary it is believed that the nutritive cells are derived from disintegrating spermatocytes (Sabatier, 1885) and more concrete evidence was given by Keppen (1906) on *Astacus fluviatilis* and Ratnavathy (1941) on *Clibanarius olivaceous*. The average number of nutritive cells and the average number of other cells (spermatocytes and spermatids) in a part of the testis in *Caridina* were observed to be almost the same. If there is a later transformation of the spermatocytes into nutritive cells by disintegration, there should have been an increase in the average count of nutritive cells. It appears that each germinal cell divides mitotically, the products being a nutritive cell and a primary spermatocyte.

Histology of vas deferens (Fig. 7)

The vas deferens has three layers, an outermost fibrous coat, a layer of circular muscle fibres and an inner glandular epithelium whose cells become columnar at places. The wall of the terminal portion of the vas deferens is thicker because of the interpolation of a sheet of longitudinal muscle fibres around the epithelial cells. The epithelium of the first limb of the vas deferens is uniform and less columnar. The cells of the glandular epithelium have large nuclei and the free ends have amoeboid appearance. Large vacuoles are observed in these incorporating the secretory products. Where the first limb gets folded on itself and proceeds as the second limb, a ridge of about dozen cells the ' typhlosole ' makes its appearance on its upper side, projecting into the cavity of the duct. The cells are taller (36 μ) with oval nuclei and have secretory vacuoles in their cytoplasm. The ' typhlosole ' shifts to the lateral side in the second limb of the vas deferens and passes into the third limb becoming less and less conspicuous at its distal part. It is interesting to note that the cells have an affinity for nuclear dyes, a condition which has also been observed in the sand crab, *Hippa pacifica* (Matthews, 1956).

Cilia as found in the deferent ducts of Crustacea (Fasten, 1917 and King, 1948) were not observed in the vas deferens of *Caridina*, except in the region of the typhlosole, where they resemble flagella although no basal granules have been observed. The flagella assist the expulsion of the sperm mass.

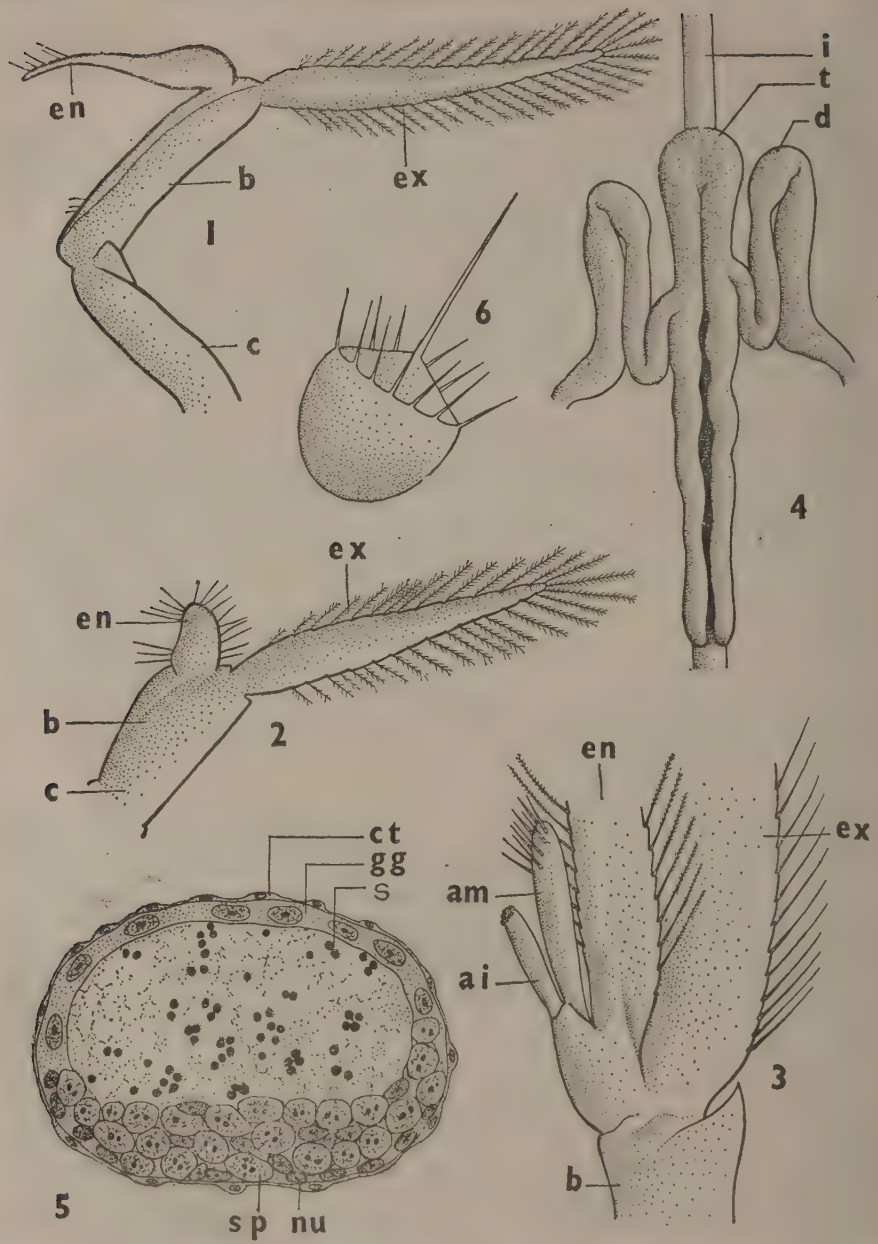

FIG. 1. First pleopod of female. b. basis, c. coxa, en. endopod, ex. exopod. 2. First pleopod of male. 3. Second pleopod of male. ai. appendix interna, am. appendix masculina. 4. Dorsal view of testis and vas deferens. d. vas deferens, i. intestine, t. testis. 5. Cross section through posterior part of testis. ct. connective tissue, gg. general germinal layer, nu. nucleus of nutritive cells, s. sperm, sp. nucleus of spermatocyte. 6. Lateral view of the sperm.

Under the phase contrast microscope the epithelium of the vas deferens shows that cells of the typhlosole have secretory vacuoles containing a secretion, secretion A, towards their distal ends. The rest of the cells also show vacuoles containing a secretion, secretion B, but of a different nature as is shown by its different staining reactions. Secretion A does not stain so intensely as secretion B in Mallory's connective tissue stain but takes a light blue colour in Heidenhain's iron haematoxylin, while secretion B does not. Secretion B is stainable deep blue in Mallory's triple stain while secretion A is not. The secretion B binds the sperms inside the first limb of the vas deferens. The secretion A of the typhlosole pushes this mass to the opposite side and gradually envelops it. Vitally stained and dissected vas deferens shows a simple, string-like spermatophore.

The development and expulsion of the spermatozoa into the deferent ducts do not appear to be a continuous process but are periodical. The nature and the secretory phase of the cells lining the first limb of the vas deferens do bear a close relationship to the stage of activity of the testis. In undernourished individuals the process of spermatogenesis is slackened, the sperm mass in the duct is thinner and the cells of the vas deferens smaller. The cells of the typhlosole have also a reduced size indicating a slackening of their secretory activity. A more or less similar appearance is presented as soon as the peak of their secretory activity is over. The cells shrink and clefts are formed among them.

The spermatozoa (Fig. 6) are extremely small, measuring about 2.8 μ across. Under the phase contrast microscope, the live spermatozoon appears like a hemisphere, at the top of which is a cone. It resembles that of *Palaemon lamarrei* in the possession of a long apical spine (Nath, 1937). In addition to this, eleven shorter spines radiate outwards all round from the junction between the cone and the hemisphere. In smears, a peripheral nuclear vesicle has also been observed.

2. The Female Reproductive System

With regard to the gross structure of the ovary, *Caridina* resembles *Palaemon malcolmsonii* (Patwardhan, 1937) and *P.idae* (Parameswaran, 1953).

Morphology of the ovary and oviduct (Fig. 8)

The ovary consists of two longitudinal columns lying in the cephalothorax and extending into the abdomen. Anteriorly the two columns are joined together. In a mature female the ovary extends from the anterior one-fourth of the carapace (measuring from the base of the rostrum) to more than three-fourths of the third abdominal segment. The oviducts arise as thin-walled tubes from the ventral side of the ovary, running downwards between the ventral muscles and the thoracic wall. They open to the outside of the inner face of the coxa of the first pair of walking legs. The genital opening in a mature female is circular. Its anterior lip bears a row of about 8-10 stout bristles and is guarded by a hinge-like transparent cuticular operculum. During ovulation the eggs coming down the oviduct push the operculum outwards and are guided backwards by the bristles.

Histology of ovary (Fig. 9)

The ovary is bounded by a layer of epithelium which is continuous with that of the wall of the oviduct. The cells forming this general epithelium are flattened with small, round nuclei. Below this there is another layer of cells which at places extends into the cavity of the ovary as numerous shelf-like invaginations. In whole

mounts of the ovary, their nuclei have been observed to undergo amitosis without any corresponding cytoplasmic division. This layer invests the developing oocytes forming follicles. In a medium sized ovary fixed in a weak solution of chromic acid, the formative region or the germogen is seen as a pale whitish streak on the lateral ventral aspect of each lobe. These streaks shift to the lower side and meet together anteriorly. The exact shape and position of the germogen is subject to variation depending upon the tension exerted by the developing ova on the ovarian wall. The germogen does not develop an invagination as in *Palaemon idae* (Parameswaran, 1953) but appears as a thickened region of the inner epithelium as in *Eupagurus* (Jackson, 1913) and *Clibanarius* (Kamalaveni, 1949).

The germogen is most active anteriorly and by far the greater number of oocytes are formed here. In a cross section of the anterior part of the ovary, the germogen appears as a multi-nucleate protoplasmic mass. The cytoplasm is granular and devoid of vacuoles. The nuclei are small and compact with usually a few clumps of chromatin. The primary oogonia derived from these have large diffuse nuclei each with a pronounced reticulum and about three chromatin clumps. The oogonium during oogenesis, divides to form an oocyte and a cluster of nutritive cells or nurse cells (Fig. 10). The number of nurse cells has been noticed to be five. Earlier in development there are clusters of five nuclei arranged in a mass of cytoplasm. These represent the nuclei of an oocyte and four nutritive cells, all derived from one oogonium. The oocyte probably divides further forming another sister cell which joins the other cluster of four nurse cells. In *Deilephila euphorbiae* (Insecta) Schneider (1917) has described a similar derivation of the nutritive cells. The cytoplasm of the nurse cells seems to be confluent at this stage. The nuclei exhibit a reticulum and the chromatin bodies are not discernible. Chromosomes of the nurse cells have been observed at about this stage but in sections it has not been possible to count them. It is possible that the nurse cells have the diploid and the oocytes, the haploid number of chromosomes as this condition is seen *Triops* (Longhurst, 1955). The oocyte eventually outgrows the nurse cells. The ultimate fate of the nurse cells have eluded investigation but based on the fact that the fragments of the nuclear system of the nurse cells have sometimes been detected inside the growing oocytes, there is reason to believe that they are absorbed into the ovum. But conclusive evidence on this point is lacking.

As the oocyte grows, the number of follicle cells investing it also increases. During this process the cytoplasm of the ovum is seen to develop vacuoles which finally are charged with yolk. These vacuoles shift towards the periphery at a slow pace. Developing oocytes cut and stained in Heidenhain's Azan demonstrate certain black staining granules which might represent the Golgi system (Thomas, 1948). Such bodies have been observed inside the dark cells of the digestive diverticula also (Pillai, 1960).

The wall of the oviduct is made up of two layers of cells, an outer epithelium, continuous with the outer epithelium of the ovary and an inner-more columnar layer. The inner layer is glandular and in a mature female becomes markedly larger. The cytoplasm becomes granular and vacuolated and the nucleus with a very conspicuous nucleolus assumes a basal position.

The growth of the ovary (Fig. 13)

A very young ovary (Fig. 13, 1) stretches from just in front of the heart to the second abdominal segment. The two lobes are uniformly thin and pale like the testis, with which it is easily confused at this stage. In the next four days (Fig. 18, 2)

it grows and extends to the hind limit of the second abdominal segment. On the outer side of each lobe the germogen appears as a longitudinal streak from which an inner row of cells becomes differentiated. These cells are large and pale yellowish. The two lobes touch each other in the first abdominal segment. In another four days, the ovary enlarges (Fig. 13, 3) and develops two to three rows of cells. The innermost row contains the largest ova which are green due to the deposition of yolk while the others are smaller and yellowish. The lobes of the ovary now press against each other in the middle line and extend upto the hind extremity of the second abdominal segment. The peripheral layer of the oocytes appears whitish. The outer two rows of cells also begin to secrete yolk, enlarge and become green. The ovary elongates further and develops a flexion below the heart. Within the next six or seven days it extends from three-fourths of the cephalothorax to more than half (Fig. 13, 4) the third abdominal segment. Some of the cells now shift downwards and hence the linear arrangement of the ova disrupts. The lobes are not usually of the same length and in the majority of cases examined, the left is longer. The outline of the egg cell becomes rounded and more defined. Ovarian flexion is more pronounced and all the ova now become alike in size and colour. They stream towards the anterior region. Posteriorly the lobes almost touch the fourth abdominal segment and anteriorly extend to more than three-fourths of the cephalothorax. The approximate minimum length of the animal at this stage is 13 mm. Within another day or two the ova are ready for extrusion and fertilization. Before mating the animal, as is well known, rndergoes ecdysis and acquires the breeding dress, mainly in the form ovigerous setae.

Chromosomes (Figs. 11 and 12).

. Squash preparations have shown that the diploid number (2n) of chromosomes is 64. Most of the chromosomes are thick and rod-shaped with subterminal centromeres. A few are relatively longer, with median or submedian constrictions. The chromosomes regularly form 32 bivalents as may be seen from the metaphase of the first reduction division of the primary spermatocyte. Embryos also yield good chromosome pictures. Eggs were dissected approximately at about 126 hours after the initiation of cleavage. The egg membranes and the mass of the yolk were teased off in normal saline and the embryonic portion was squashed. This also revealed the diploid number of 64 chromosomes.

3. Breeding Habits and Breeding

Copulation

Caridina generally mates only in darkness. However, fully mature specimens kept in the aquaria were observed to mate in shaded blue light. Copulation, followed by spawning, continues to take place for 4 or 5 days after they are captured from the field. Individuals kept for more than this period lose their vigour in the aquarium and seldom spawn. Mating usually takes place between 3 a.m. and 6 a.m. The moulted female before mating is lethargic and staggers on the bottom of the aquarium. A mature male in the vicinity on passing its feelers over the moulted female, stands still, its antennae alone hovering about the female. Then it approaches and clasps the female. He applies his ventral side close against the ventral part of the female and effects a few quick convulsive movements.

A female specimen which was fixed at the time of extrusion of eggs revealed a few sperms inside the ultimate portion of the oviduct. How the nonmotile sperms ascend the oviduct has not been understood. During the process of mating, the

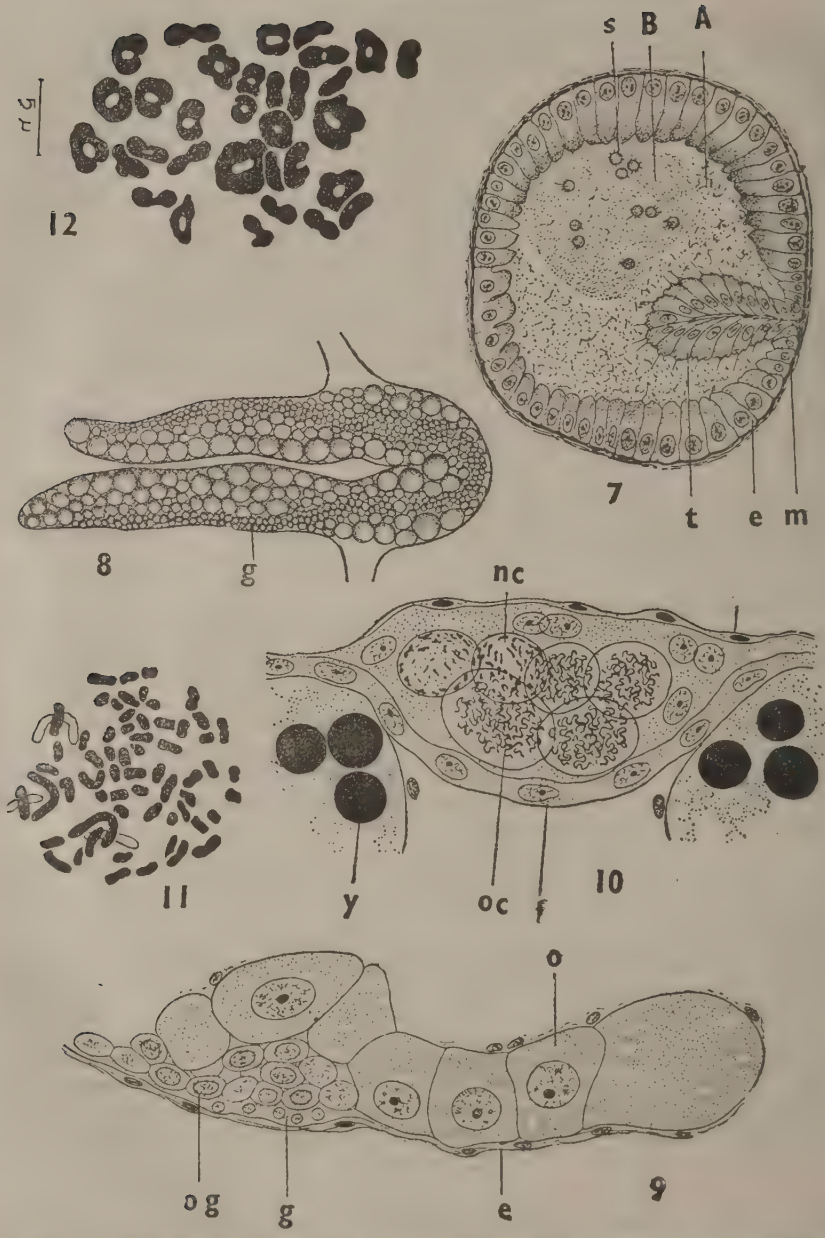

FIG. 7. Cross section through second limb of the vas deferens. A. secretion, A. B. secretion B, e. epithelium, m. fibrous coat with muscle layer, s. spermatozoa t. typhlosole. 8. Ventral view of a growing ovary. g. germogen. 9. Section through germogen of a mature ovary. e. epithelium, o. oocyte, og. oogonia. 10. Magnified view of a portion of germogen showing nurse cells. f. follicle cells, nc. nucleus of nurse cell, oc. nucleus of oocyte, y. yolk granules. 11. Polar view of metaphase of the equational division of the spermatogonia. 12. Polar view of the metaphase of the first reduction division of the primary spermatocyte.

sperm mass, as it emerges from the male genital opening is caught by the appendix masculina and is shoved into the female genital opening. The mass of sperms blocks this orifice and as the ova are squeezed out of the female genital opening, probably the contents of the oviduct are sucked upwards which result in a few spermatozoa also being drawn in.

Extrusion of eggs.

The process of extrusion of eggs commences soon after copulation and the first egg takes the maximum time of more than one minute to be extruded. The ova nearer to the oviducts are extruded first. Inside the ovary where the ova are pressing for space, the liberation of one ovum would produce a zone of low pressure towards where the other ova naturally get pushed breaking their incomplete follicular envelops. The diameter of the ova being larger than that of the oviduct, they get distorted considerably while streaming out. Since the number of eggs varies from 14 to 46, the time taken for the extrusion also is subject to variation. Normally it occupies from 40 to 50 minutes. The eggs are shovelled backwards by the endopodites of the first pair of pleopods. Eggs liberated first get cemented to the anterior pleopods ; later ones are passed on to the more posterior appendages. Eggs were seen to be carried exclusively by the first three pairs of pleopods in 89% of the specimens examined, their number decreasing in an anteroposterior direction. The fourth pair of pleopods in 11% alone were seen to carry one egg each. In all the cases these develop ovigerous setae unlike the fifth pair which do not develop them at all.

According to Forster (1951) the mating process appears to be a response to chemical stimuli rather than visual. It is only to an immediately moulted female that the male is aroused, the necessary stimulus being obtained while passing the olfactory antennular feelers over its body. The general mating behaviour of *C. laevis* also is broadly similar to that in other Caridea. The body of the male specimen is seen to be placed along the long axis of the female in *Caridina* while in *Crangon* the body assumes a U-shaped form and is placed transversely across the female (Lloyd and Yonge 1947). The sliding movements observed in *Crangon crangon* (Nouvel 1939) have not been observed in *Crangon vulgaris* (Lloyd and Yonge 1947). In *Caridina* certain convulsive movements have been observed instead which are probably for the expulsion of the spermatophoral mass. In *Crangon* spawning takes place two days after moulting irrespective of copulation (Lloyd and Yonge 1947). If copulation has taken place after moulting spawning is expedited and is brought about in 24 hours. Spawning takes place immediately after copulation if the specimen belongs to a small size group Nouvel (1939). In the larger ones it takes place after 24 hours and in the largest within 48 hours. It appears that there is a relationship between the size of the animal and the interval between copulation and spawning. And in *Caridina* which is smaller than the smallest mature female of *Crangon* spawning takes place immediately after copulation.

In most of the forms where the reproductive biology has been studied, spawning is clearly seasonal [*Crangon* Lloyd and Yonge (1947) and Meredith (1950-52) ; *Pandalus* Pike (1953) etc.] But the present data do not indicate any seasonal breeding in *Caridina*. Berried females are obtained throughout the year, their number showing a slight increase soon after the Monsoon which fact has been reported by Nair (1949) also. The lack of a well defined breeding season in *Caridina* is possibly due to (1) the animals being inhabitants of ponds, ditches and other small freshwater bodies where environmental fluctuation is too varied to clearly mark the seasons and (2) the development and maturation of the ova and the spawning being

quicker than in other forms. In seven specimens where the growth and maturation were studied, the total number of days between one spawning and the other varied from 32 to 38. It may also be noticed that the eggs hatch out quicker. In the above seven specimens it varied from two weeks and a half to three. Nair (1949) has observed the period to be 17 days.

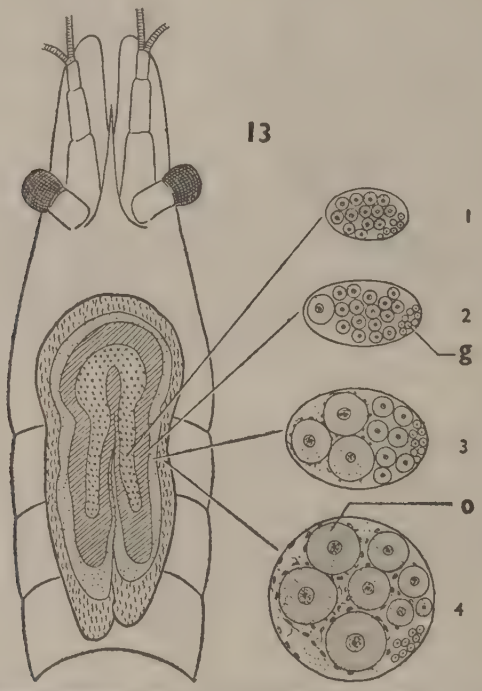

FIG. 13. Diagrammatic representation of the growth of the ovary. 1-4. cross section of the ovary at various stages indicated (not to scale).

SUMMARY

The generative organs are two simple tubes, connected together in front. Each germinal cell in the male appears to divide mitotically into a nutritive cell and a primary spermatocyte. The 'typhlosole' and the rest of the glandular epithelium of the vas deferens each produces a secretion which binds and envelops the spermatozoa, resulting in the formation of a simple threadlike spermatophore. During oogenesis, the five nurse cells which are formed in association with the oocyte possibly are absorbed by the latter. The growth of the ovary has been traced and in a mature animal ready for fertilization it occupies three-fourths of the length of the cephalothorax apart from the first three abdominal segments. Copulation, observable in shaded light between 3 a.m. and 6 a.m. is a very quick process. Extrusion of eggs takes place soon after copulation and takes about 40 to 50 minutes. Squash preparations of the testis and embryo reveal the diploid number of chromosomes as 64.

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I am deeply indebted to Dr. K. Bhaskaran Nair, Professor of Zoology, University College, Trivandrum, for his invaluable help and guidance. I thank the Government of India for the award of a Research Scholarship and the administration of the University College for the facilities so generously afforded for pursuing the work. My thanks are also due to Dr. K. K. Nayar for his valuable suggestions.

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ON THE CASTLE BUILDING HABIT OF THE CRAB *CARDISOMA CARNIFEX* (HERBST) (FAMILY GEOCARCINIDAE), OF THE ANDAMAN ISLANDS[1]

By E. G. Silas and C. Sankarankutty
Central Marine Fisheries Research Station, Mandapam Camp

Our knowledge of the ecology and habits of land crabs of the family Geocarcinidae, especially of the genus *Cardisoma* is wanting in several respects. In the tropical Indo-Pacific, where two species of this genus are recognised, the available information is restricted to stray observations, mostly pertaining to locality records.

During a recent visit to the Andamans and Nicobar Islands in February-March 1960, we were interested to see in several places close to the shore in Andamans, characteristic earthen mounds, some of exceptionally large size and each resembling a termitarium. A close scrutiny showed that the mounds were crab castles, and in some fields several of these castles of varying sizes were seen generally ranging in height between 30 and 50 cms. and spread out almost to the shoreline. The largest of such aggregations both in numbers and size we found in places adjacent to Phoenix Bay, Port Blair, and at Mayabundur, where each mound was about 75 cms. high with an almost equal basal diameter. Although we were told that several hundreds of these crabs teem over the colony areas and adjacent fields at night, this was not to be the case, atleast during the period of our visit and only on the last night of our stay at Port Blair were we able to catch one of the crabs from a colony near Marine Drive, Aberdeen Bay which we visited or passed by at different hours of the night as well as during day time when observations were made. The crab is a large female *Cardisoma carnifex* (Herbst) (Plate I, fig. 2), a species having a fairly wide distribution in the tropical Indo-Pacific.

It is somewhat surprising that in spite of there being several accounts on the natural history of the Andamans and Nicobar islands (Alcock, 1902 ; Kloss, 1902 ; Temple, 1903 ; Sewell, 1922 ; etc.), this phenomenon of castle building by *C. carnifex*, so conspicuous a feature of the topography of some of the shore areas has not found mention in them. This species is nocturnal and contrary to expectation even at night they were not found to stray away from their respective castles or open burrows (in places where castles were not yet constructed or only partly finished). Commenting on the habits of *C. carnifex* from the Tuticorin coast (Gulf of Mannar), Henderson (1893) remarked that ' . . . . its underground dwellings, unlike those of most land crabs, do not pass vertically downwards for the first part of their course ; they also lack the neat and finished appearance of the external opening, seen in the burrows of most Telphusae '. This we found to be the case where the crabs had not yet constructed their castles, but in the latter case, the main burrow from its opening near the summit drops vertically to the ground level from whence the burrow slants. Borradaile (1901) remarks that *C. carnifex* ' Generally makes its burrows under coconut trees at the edges of *Kuli* or swamps, the openings being

[1] Published with the permission of the Chief Research Officer, Central Marine Fisheries Research Station, Mandapam Camp.

often covered at high tide.' In the case of open burrows as well as the castles, invariably the entrance was seen to be plugged during day time. Each period of activity appeared to be marked by fresh layers of excavated earth at the burrow openings or at the summit of the castles. These additions are in the form of large irregular pellets copiously mixed with water making them firmly adhere to the previous layer, thus forming a compact mass, but when too watery the wet mud drips along the sides of the castle (Plate I, fig. 1, *a*). Many of the castles, in addition to the main burrow opening at the top had one or two openings at the base which remained similarly plugged (Plate I, fig. 1, *b*). It was not possible to verify whether these tunnels were always kept open during the periods of activity. As in the case of the double exit openings of the U-shaped burrows of some ocypodids, these probably represent means of easy access or exit for the crab when disturbed during its period of activity.

Unlike the scattered accumulation of sand outside the burrow entrances of ocypodids, the castle building habits of *C. carnifex* appears to be executed for some purpose for many reasons. Besides the initial excavation of earth in constructing the burrow, their close proximity to the shore naturally subject the tunnels to tidal influence. During the high tide period seepage water is likely to enter the burrows and the wet earth excavated during ebb tide to clear the tunnels will account for much accumulation of the earth at the burrow entrance, but their orderly placement eventually to form the castle is amazing. Compared to *C. carnifex*, the castles of the land crab *Paratelphusa guerini* (M. Eds.) are but miniature replicas and McCann (1937) remarks that the latter are constructed to keep off intruders for 'At the time that the crab is about to aestivate there are numerous other animals which are looking for a suitable retreat. Some are unable to excavate their own burrows ; others prefer to find a convenient ready made burrow rather than dig one, and find a crab hole convenient. If the entrance of the crab's burrow were flush with the ground, the entrance with its fresh plug of mud would be readily accessible. But as the entrance is raised and the wall of the castle solid they act as a bluff which is mistaken for a clod of earth!' Protection from intruders may also be a plausible reason for *C. carnifex* to resort to this castle building habit. However, unlike *Paratelphusa* which perforce aestivates during the dry months when the water level in the soil goes down, the daily tidal fluctuations affecting the shore areas inhabited by *C. carnifex* may not allow for any quiescence unless aestivation is carried out above the ground level in the castle itself.

The movements of the crabs around the burrow openings and the castles appeared extremely sluggish, but at the slightest disturbance they darted into the burrows, entering sidewise, and in the open burrows were invariably found lingering partly hidden at the point where the burrow disappears from view. Only once at night did we notice a crab about ten metres away from some open burrows into one of which it fled when disturbed.

As to whether these castles are permanent structures or not we are unable to say. Our visit was about two months after the monsoon was over and most of the castles appeared to have been built since then. Although many of the fields in which the castles were present were found to be overgrown with weeds and grass, the castle walls were bereft of any encrusting vegetation, thus pointing to their recent construction. In contrast, one of the fields off Marine Drive and just to one side of the Andamans Club, Port Blair, is studded with numerous small dome-shaped mounds not exceeding 25 cm. in height, but covered with grass, which no doubt represents a disused colony, the castles themselves having been obviously planed down by rain action.

1. Castles of *Cardisoma carnifex* (Herbst). (*a*) Recent addition to the summit of the castle with the main burrow opening at the summit plugged ; (*b*) Clods of fresh earth covering a secondary opening near the base of the castle.

2. *Cardisoma carnifex* (Herbst). Female, caught from one of the colonies at Port Blair, Andamans.

In the Chilka lake, *C. carnifex* occurs in the islands in the outer channel near Manikapatnam, and Kemp (1915) observes that ' In March 1914, when the water was low and as salt as that of the sea outside the lake, large burrows of *C. carnifex* were found, their mouths often four or five inches in diameter. Similar burrows were noticed below the surface of water in the vicinity and, on the shore, fragments of specimens that had been eaten by birds were abundant. In September, when the water in the outer channel was fresh, the species was also in evidence, but on this occasion, owing to the rise in the water-level, most of the burrows were below the surface. The crabs seem to live at a considerable depth in the mud and as a rule, do not wander by day ; it was in consequence difficult to obtain specimens.' We found no remains of the crab or its moulted shell in any of the colony areas. However, it is likely that in low-lying places subject to inundation during the rains the open burrows may be covered with water.

Alcock (1900) records both *C. carnifex*, and *C. hirtipes* Dana from Andamans and remarks that these species are ' . . . . very common in the jungles of Andamans where they may be found in the day time crouching under roots, fallen logs, etc., sometimes in burrows near the shore.' The ecological niches occupied by these two species are also of interest. In the Great Cocos Island of the Andaman-group, Alcock (1902) has found *C. hirtipes* occurring along with large Coenobites in the thick jungles. This species he records along with *Pleocarcinus humei* (Wood-Mason) which especially on the smaller islands grow to a large size. Further evidence that *C. hirtipes* lives away from the shore comes from the observations of Dr. C. Andrews on this species from the Christmas Island in the Indian Ocean, cited by Calman (1911) wherein it is stated that ' In this island at any rate this species must be regarded as a freshwater form, and, in fact, when a specimen was seen it might be taken as an indication that freshwater was not far off. It lives in deep holes in the mud at the sides and bottom of brooks.' In addition Calman mentions that ' Dr. Andrews tells me that he never saw this species at or near the sea (in marked contrast to *Gecarcoidea*) and this agrees with the observations of other travellers on species of the genus *Cardisoma*, so that the breeding habits remain unknown. There is every possibility, however, that in this case also, the young stages are passed in the sea.' In the Aldabra, Fryer (1911) found *Cardisoma* (species not mentioned) which are preyed upon by the common rat *Mus rattus*, acting as a general scavenger, but resorting to digging burrows in the vicinity of wells and filling them with dirt so as to make the water undrinkable. During our visit to Neill Island and Long Island in the Andaman-group we found further away from the shore at the bases of several very large trees and fallen trunks deep crab burrows with excavated earth accumulated on one side of the burrows. In Neill Island these were also present in the areas bordering a freshwater swamp. Unfortunately specimens of crabs from such situations could not be collected. However, after witnessing the castle building habits of *C. carnifex* and from the accounts of Alcock (1900, 1902), Borradaile (1901), and Calman (1911) we are inclined to believe that the burrows in the interior of these islands were those of *C. hirtipes* or *P. humei* and not those of *C. carnifex*. Fryer's account of the species of *Cardisoma* polluting well water may also refer to *C. hitripes*. Here is an interesting case of zonation where one species, (*C. carnifex*) is a shore dweller, atleast seasonally constructing castles above their underground dwellings and being more tolerant to salinity while its congener (*C. hirtipes*) lives far removed from the shore, preferably near freshwater resources, does not resort to castle building, and is probably also less tolerant to salinity.

Considering these, one question that needs solving is whether the castle building habit of *C. carnifex* is the result of a response to any special ecological feature such

as, the daily tidal fluctuations which is of considerable magnitude in the Andamans. If this be the case, the species may be expected to evince such a behavioural pattern wherever it occurs along coasts subjected to such tidal fluctuations. On the other hand, if the habit is localised, it will be worth investigating whether such a specialised behavioural pattern has any taxonomic significance as well.

No doubt, the gaps in our knowledge of the habits and natural history of these two species of *Cardisoma* are immense and more detailed observations are called for. Lack of time and other pressing duties kept us from extending our observations, but what little we saw of these crabs was so interesting that we have felt it desirable to report on the same. Any reader who has unique opportunities to observe *C. carnifex* in nature could unravel the mysteries surrounding its natural history, especially on questions whether there is any social hiearchy in the colonies, whether they aestivate at all, their breeding habits, etc., and thus needless to say, will be doing a great service to the science of Carcinology.

Acknowledgement

We are very thankful to Dr. S. Jones, Chief Research Officer, Central Marine Fisheries Research Station, Mandapam Camp, for permitting us to accompany him to the Andamans and Nicobar Islands which has enabled us to make these observations.

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J. Mar. biol. Ass. India, 1960, 2 (2) : 241-249

PHYLLOSOMAS OF SCYLLARID LOBSTERS FROM THE ARABIAN SEA*

By R. Raghu Prasad and P. R. S. Tampi
Central Marine Fisheries Research Station, Mandapam Camp

Introduction

In an earlier paper (1957) the authors described a few phyllosomas of scyllarids collected from the Gulf of Mannar near Mandapam and so far this seems to be the only account of the larvae of these lobsters from Indian waters. The difficulty in establishing the specific identity of the various types of phyllosomas has been experienced by all workers. Only in a few instances, such as *Scyllarus arctus* (*ref.* Stephensen, 1928 and other earlier workers referred to by him), the monospecific *Thenus orientalis* (*ref.* Prasad and Tampi, 1957), and *Ibacus ciliatus* (*ref.* Harda, 1958) has it been possible to obtain the larvae hatched from the eggs and thus establish identity beyond doubt while at present identification of many other scyllarid larvae will necessarily have to be based on circumstantial evidence. The problem is particularly difficult in the case of Indian scyllarids. Meanwhile it has been possible to obtain some scyllarid phyllosomas and nisto stages from the region around the Laccadive islands (Fig. 1) during the cruises of the research vessel KALAVA in 1958 and 1959. A brief account of these phyllosomas is given in the present paper while the natant stages will be described at a later date along with similar material collected along our coast.

The authors are grateful to Dr. S. Jones, Chief Research Officer, for looking through the manuscript and for lending reprints of some of the papers from his personal library. Thanks are due to Shri C. T. Rajan for sorting out the larvae.

Description of Phyllosomas

All phyllosomas described below have more or less the same basic characteristics assigned to the scyllarid phyllosomas by Gurney (1936), *viz.*, a fore-body that is wider than long and a much narrower hind body, an abdomen which is broad at its base in late stages, second antenna that is usually much shorter than the first in the beginning and later becoming a broad, flat and bilobed structure, first maxilla without palp, third maxillipede without setose exopod and pereiopods with only short dactyls.

Scyllarus sp., I

Eight larvæ of different sizes of what we consider as five distinct stages of the same species were present in the collections as per details given in the table below.

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Table on collections of *Scyllarus* sp., I.

Date	*Station*	*Length* (mm)	*Approx. Stage*	*Figure No.*
29.4.59	448	1.60	*II*	2
29.4.59	448	3.40	*V*	3
29.4.59	Near Agatti	4.40		4
29.4.59	448	4.65	*VI* or *VII*	
29.4.59	Near Agatti	4.76		
29.4.59	Near Agatti	4.98		
29.4.59	Near Agatti	8.00	*VII* or *VIII*	5
29.4.59	Near Agatti	11.50	*X*	6

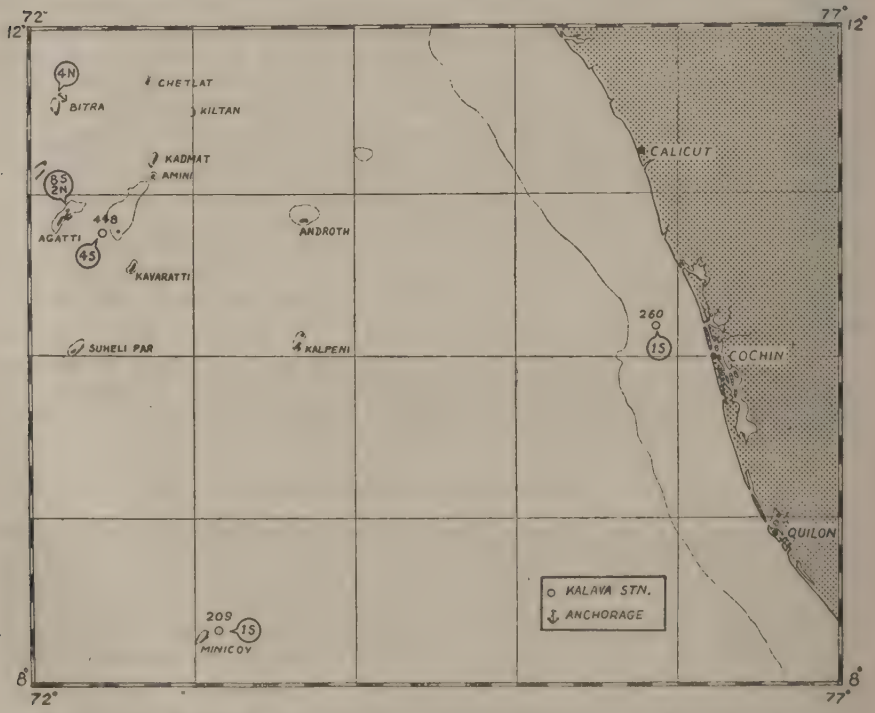


FIG. 1. Map showing the stations from where scyllarid phyllosomas and nistos were obtained. The numbers in circles indicate the number of larvae (S, for phyllosomas and N, for nistos) collected at each station.

Fig. 2, A-D.

The larva has a fore-body as broad as long with a slightly tapering posterior border. The hind-body is much narrower than the fore-body. The eye possesses a stalk, the first antenna is twice as long as the second and in place of the inner flagellum is a single seta. The second antenna consists of a single segment. Second

maxilla possesses a small apical segment with 4 plumose setae on an elongated basal segment. The first maxillipede is hardly recognisable while the second and third are uniramous appendages, the latter being slender and as long as the pereiopods. Both the first and second pereiopods are fully developed with setose exopods, whereas in the third the exopod is only a small non-setose segment. The fourth pereiopod, present as an unsegmented rudiment, is as long as the abdomen. The third maxillipede as well as the three pereiopods each has a coxal spine. Another spine is present on the basipod at the point of articulation of the exopod. Dactyls in these walking legs are short. Abdomen is short, ending in a pair of strong spines (broken in the specimen and indicated by dotted lines in the figure).

The articulated nature of the eyes, the non-setose but relatively long exopod segment in third pereiopod and the presence of the rudimentary fourth pereiopod suggest that this larva belongs to Stage *II* in a developmental series.

Fig. 3, *A-D*

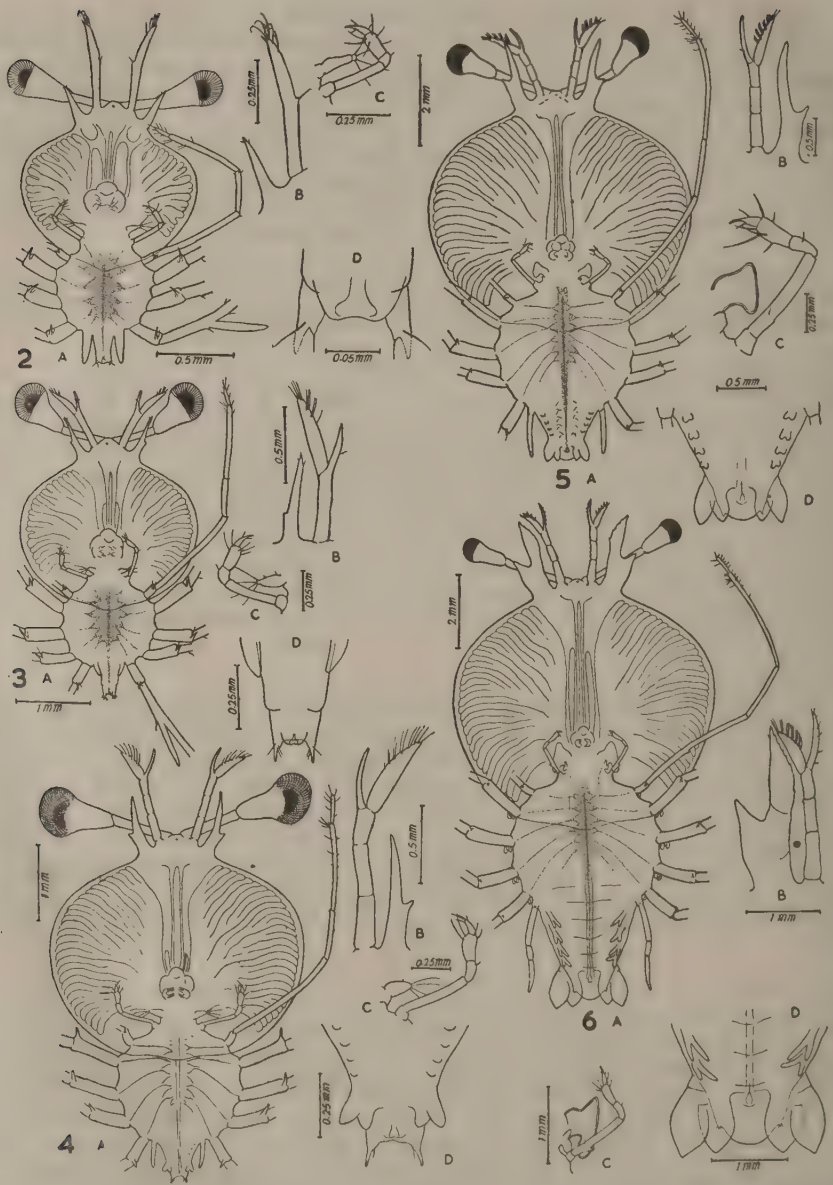
The width of the fore-body is nearly the same as its length and the broadest region is almost in the middle. The first antenna shows an inner flagellum. The second antenna is more than half the length of the former with a rudimentary outer process. Maxilla, maxillipede and the first two pereiopods are the same as in the earlier larva, while the exopod of the third pereiopod is fully formed. The fourth pereiopod is also well developed except for the non-setose single segmented exopod. Fifth pereiopod is seen as a rudiment. Changes in the abdomen are not appreciable from the previous larva except that the prominence of the uropods is evident. The structure of the appendages indicates a considerable advance in development in this larva leaving a wide gap between this and the larva described earlier so that it seems justifiable to consider this as belonging to Stage *V*.

Fig. 4, *A-D*

There are four larvae ranging in length from 4.40 to 4.98 mm. in the same collection, all of which appear to be in the same stage of development (regarded as Stage *VI* or *VII*) and the one of 4.40 mm. is figured here. The three segments of the antennular peduncle are indicated and the outer process of the second antenna is more pronounced. The second maxilla and second maxillipede remain without much change but the marginal setae of the second maxilla are wanting in the 4.98 mm. specimen. The fourth pereiopod is fully formed with a setose exopod while the fifth is composed of only one segment, nearly three-quarter the length of the abdomen. The most significant character of the larvae is their abdomen which is broad at the base with terminal spines and rudiments of uropods and pleopods.

Fig. 5, *A-D*

The resemblance with the earlier stage in the shape of the shield, abdomen and appendages is evident. The second antenna is shorter than the first. The second maxilla has flattened and is devoid of marginal setae. The rudimentary first maxillipede is more prominent than in all earlier larvae and the indication of an exopod of the second maxillipede is seen. The fifth pereiopod is nearly as long as the abdomen but the coxal segment alone is demarcated. Excepting on this leg coxal spines are present in others and on the third maxillipede, but these are less conspicuous than in the larvae described earlier. Pleopods are in the form of low biramous buds. The uropods are leaf-like and the telson shows a pair of small marginal spines. The characters of these larvae indicate a stage following the earlier one, shown in Fig. 4.



FIGS. 2-6. Different stages of *Scyllarus* sp., I: 2, Stage *II*; 3, Stage *III*; 4, Stage *VI* (*VII*?); 5, Stage *VII* (*VIII*?); 6, Stage *X*. A. phyllosoma larva; B. First and second antennae; C. Second maxilla and second maxillipede; D. Abdomen. This lettering holds good for figures 2-11.

Fig. 6, A-D

A slight change in the shape of the shield from that of the previous larva is noticed and this phyllosoma seems to be fairly well advanced in development. The second antenna is as long as the first, flat and distinctly bilobed, the inner process shows segmentation and bears a few marginal setae. Second maxilla is flat and without marginal setae. First maxillipede is bilobed, and a rudimentary bud of the exopod is seen on both the second and third maxillipedes. Gills are present on the coxal segments of the third maxillipede and the first four pereiopods while the fifth one does not possess gills. This pereiopod is as long as the abdomen and divided into 3 segments besides the coxa which bears a small spine. The abdomen itself is about 2.5 mm. long and shows considerable change from that of the larva described earlier. Segmentation is clear, the pleopods are long and biramous and the uropods are also well developed. The telson retains the pair of marginal spines.

The authors are inclined to place this larva in Stage *X*, and judging from the development of the second antenna, maxillipedes and pleopods, this might as well represent the last stage in the series of phyllosomas before metamorphosing into the natant stage.

It might be mentioned here that this larva corresponds in its developmental stage to the one described by us earlier as phyllosoma *VII* (1957, Fig. 12, page 65). However, there are differences in the shape of the fore- and hind-body in the two larvae, the relative length of the antennae and the presence of the exopod rudiment on third maxillipede indicating that these two larvae belong to two distinct species.

Scyllarus sp., II

Two larvae, 2.8 mm. (Fig. 7A) and 6.75 mm. (Fig. 8A) in length, were obtained on 29-4-1959 at station 448 and from an anchor station near Agatti respectively.

Fig. 7, A-D

The fore-body is wider than long, and twice as broad as the hind-body. The inner flagellum of the first antenna has developed ; the second antenna is slightly longer than the antennular peduncle and shows the rudiment of the outer branch. Second maxilla is composed of two segments, the small terminal one bears four plumose setae. First maxillipede resembles those of other scyllarid larvae and has no exopod at this stage. The same description applies to the third maxillipede also. Four pereiopods are well developed although the fourth one shows only a rudimentary exopod. All the pereiopods and the third maxillipede possess coxal spines ; besides, the pereiopods have another spine on the basipod adjacent to the exopod. The dactyls are short and almost claw-like. The fifth pereiopod is present as a bud closely apposed to the abdomen. The abdomen is broad at the base and terminates in a pair of spines. Indications of the uropods are also seen.

Fig. 8, A-D

The broadest portion of the shield is near its anterior region. The fore-body is wider than long and is twice as broad as the hind-body. The antennular peduncle is distinctly three segmented and the inner flagellum is prominent. The second antenna is bilobed, the outer process being nearly as large as the inner and the whole antenna itself is longer than the antennular peduncle. Second maxilla is flat and destitute of marginal setae ; first maxillipede is rudimentary ; the second maxillipede shows indication of a developing exopod. The four pereiopods have the setose

exopod, spine on the coxa and the basipod and also rudiments of gills which are visible only from the dorsal side. The three segmented fifth pereiopod, which is as long as the abdomen, also shows a minute coxal spine. The base of the abdomen is relatively broad. Four pairs of deeply cleft pleopods, well developed uropods and a telson with a pair of strong spines are present.

Both these phyllosomas, which evidently belong to the same species, differ from those described as Species I or others described by us in our earlier publication (1957) in the size, shape of the shield and other characters. Compared to the developmental stages of these larvae with other known forms, the phyllosoma shown in Fig. 7 seems to represent Stage *III* or *IV* while the one in Fig. 8 might belong to Stage *VII*.

Scyllarus sp., III

A single phyllosoma (Fig. 9, A-D) obtained in the collections outside Minicoy Reef on 20/21-2-1958 and measuring 19.0 mm. is the largest scyllarid larva so far obtained by us. The shield is as broad as long and the width of the hind-body is nearly two-thirds that of the fore-body. The first antenna shows a three segmented peduncle and a well developed inner flagellum. Second antenna is flat, bilobed and two segmented and only slightly shorter than the first antenna. The leaf-like second maxilla has a few short hairs on the inner margin. The first maxillipede is a bilobed bud. Both the second and third maxillipedes have a rudimentary exopod. Gills and coxal spines are present on the third maxillipede as well as on all the pereiopods although the fifth leg is only uniramous and as long as the abdomen. The spine on the basipod is prominent on the first 4 legs. Deeply cleft pleopods, well developed uropods and a telson with two spines are present.

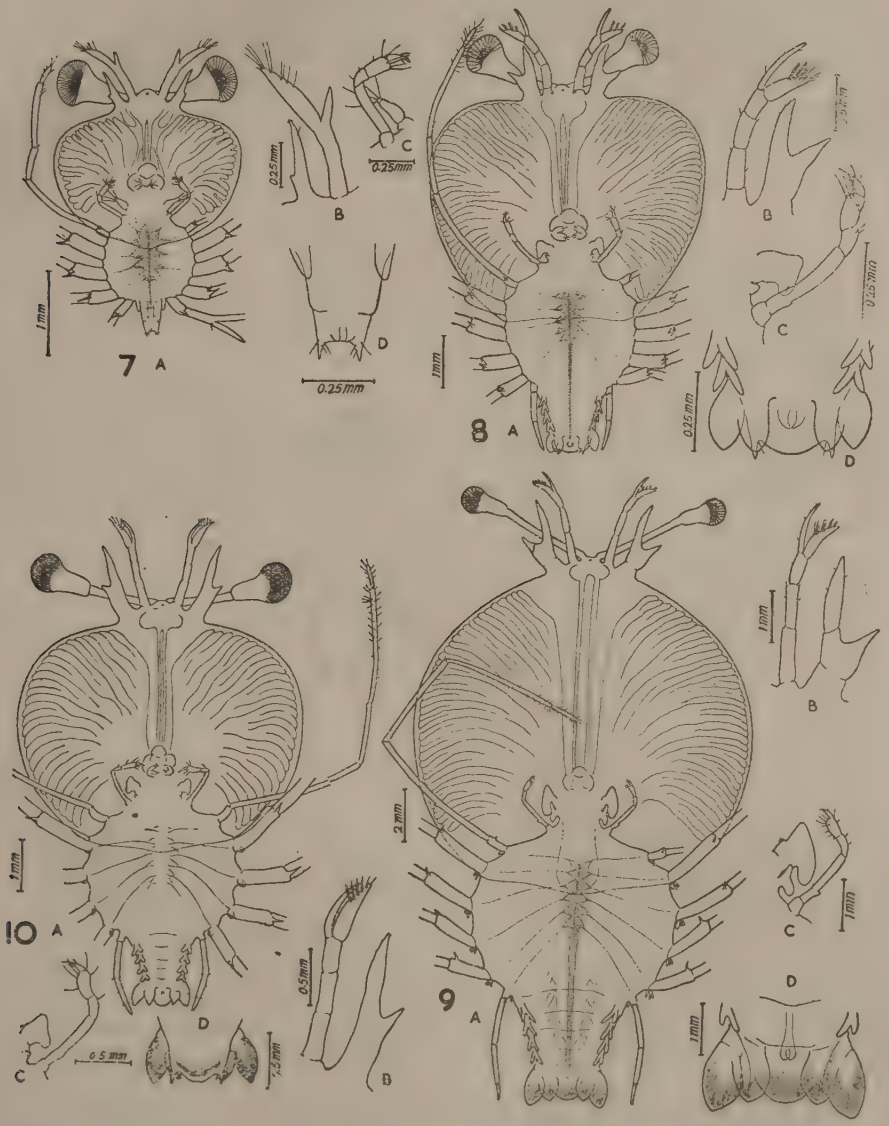
This represents an advanced larva, probably belonging to the last stage (Stage *X*) considering the development of the maxillipedes, gills and the abdominal appendages.

Scyllarus sp., IV

Two larvae (7.5 mm. and 7.8 mm. long) were obtained in the midnight collections (00. 30 hours) near Agatti on 29-4-1959 and the larger one is figured here (Fig. 10, A-D). The shield is broader than long and the width of the hind-body is slightly more than half that of the fore-body. Both the first and second antennae are well developed and both are nearly of the same length. The inner process of the second antenna shows three minute marginal teeth. Second maxilla consists of a single flat segment. First maxillipede is rudimentary, neither the second or third maxillipede possesses an exopod although it may be seen as a slight protuberance on the second maxillipede. The 4 fully formed pereiopods have moderately long coxal spines and prominent spines on the basipods at the articulation of the exopod. Fifth pereiopod is 3-4 segmented and is a little longer than the abdomen. Rudiments of gills are present on the four pereiopods which may be seen better from the dorsal side. Abdomen is broad at the base. Pleopods are cleft buds while the uropods are well developed. The telson of this larva also shows the two spines.

In the proportion of the fore- and hind-body and the stage of development of the appendages compared to the size of the larva, this phyllosoma differs from

all those described earlier in this account. Probably there might occur two more stages before passing on to the natant stage, that these can be provisionally placed in Stage *VIII*.



FIGS. 7 & 8. Show Stages *III* (*IV*?) and *VII* respectively of *Scyllarus* sp., II. 9. *Scyllarus* sp., III. (Stage *X*). 10. *Scyllarus* sp., IV. (Stage *VIII*).

Scyllarides sp.

A single larva 9.5 mm. long (Fig. 11, A-D) was present in the collections from Station 260 on 15-4-1958, which is different from the phyllosoma of *Scyllarus* spp. The most striking feature of this larva is the somewhat trapezoid shape of the shield with the broadest portion near the anterior region. The hind-body is only half as broad as the fore-body and, compared to the other scyllarid larvae mentioned in this account, the abdomen is much longer being as long as the hind-body. The first and second antennae are well developed, the inner process of the latter is as long as the first antenna while its outer lobe is flattened and bears two marginal teeth.

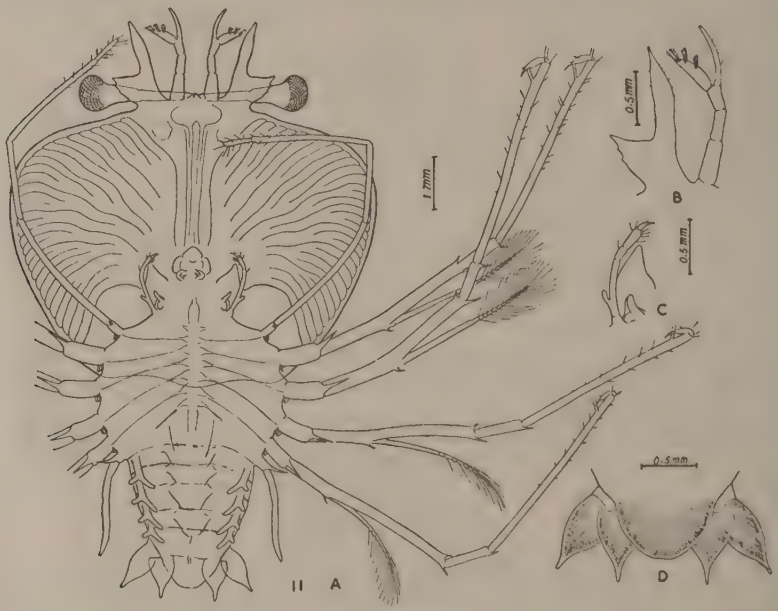


FIG. 11. *Scyllarides* sp.

Second maxilla is greatly enlarged and leaf-like. The first maxillipede is bilobed and is prominent, the second maxillipede has a rudimentary exopod while the exopod is absent in the third maxillipede. Four perciopods are well developed, each having a long coxal spine, longer than those in the larvae of *Scyllarus* spp., and a spine on the basipod near the articulation of the exopod. The dactyles are also short. The fifth leg which is uniramous and shorter than the abdomen, has four segments and possesses a prominent coxal spine. But gills are present only in the first four legs besides the third maxillipede. Pleopods are biramous buds. Uropods are leaf-like with an acutely drawn out tip while the telson has a rounded entire margin devoid of spines which seem to be other characteristic feature of this particular larva.

The resemblance of this phyllosoma with the larva described by Gurney (1936, Fig. 37, page 432) as of *Scyllarides* is note-worthy although the stage of development and the sizes do not quite tally. The similarity in the general form of the

two larvae, their antennae, legs with long coxal spines and the abdominal appendages are particularly striking although there is some difference in the shape of the uropods and the absence of exopod rudiment in the third maxillipede of the present form. Stephensen's (1923) description of what he believed to be the larva of *Scyllarides latus* show a pair of long apical spines on the telson in a stage corresponding to Stage *IV* of *Scyllarus arctus*. Since the present larva is relatively more advanced it is possible that the apical spines are lost in these later stages and the authors consider the present larva as belonging to a species of *Scyllarides*. Only two species of *Scyllarides*, viz., *S. elisabethae* and *S. squamosus* have been mentioned in Barnard's recent account (1950) of the South African lobsters, of which the latter is considered as the Mauritius species. Besides these there is very little information on the distribution of the genus in Indian waters.

Summary

The paper describes the phyllosomas of four species of *Scyllarus* and one of *Scyllarides*, collected from west coast of India.

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ON THE NEWLY HATCHED PHYLLOSOMA OF *SCYLLARUS SORDIDUS* (STIMPSON)*

By R. Raghu Prasad and P. R. S. Tampi

Central Marine Fisheries Research Station, Mandapam Camp

Introduction

Palinurid lobsters are easily obtainable along the Indian coast but among the scyllarids only *Thenus orientalis* has so far been found to be common, although besides this about twelve species belonging to *Scyllarus*, *Scyllarides* and *Parribacus* have been recorded from our waters. Nevertheless, the occurrence of different types of scyllarid phyllosomas in the seas surrounding our coast has been observed by the authors (1957 and 1960) and constant efforts are being made to collect the various adult forms and also to ascertain the species to which the different types of larvae belong. Recently the authors were able to obtain in the shore seine catches from the Gulf of Mannar near Mandapam, during the months of January and February, several adults of *Scyllarus sordidus* both males and berried females. De Man (1916) mentions this species as occurring in the Gulf of Mannar and remarks that the adults are usually found in shallow waters inhabiting coral reefs or places where the bottom is composed of sand and shells. This species, however, has not been reported from the Gulf of Mannar since De Man's account.

The berried females were kept in the aquarium and the larvae were successfully hatched out, a description of which forms the subject matter of this paper.

The authors are grateful to Dr. S. Jones for the interest he has shown in this work and to Shri C. Sankarankutty for the help rendered in collecting the material.

Description of the Larva

The eggs hatch directly into the phyllosoma. The fully expanded larvae that begin to swim about measure on an average 1.05 mm. in length. Chromatophores are distributed on the body and appendages as indicated in Fig. 1 A and are orange red in colour. The base of the eyes is not demarcated into a distinct stalk. The first antenna (Fig. 1 B) is longer than the eye, bears three long setae and a short one at the distal end and also another short seta almost at the middle of its length. The second antenna (Fig. 1 C) is relatively short and broad and is only about one-fifth of the first antenna. It bears two prominent setae near the distal end. The second maxilla consists of two segments, the distal one being small and bearing four plumose setae (Fig. 1 D). The first maxillipede is not visible at this stage, whereas the second maxillipede has five segments and is without an exopod. The third maxillipede is uniramous as in the larvae of most scyllarids. There are three pereiopods of which the first and the second have well developed exopods with natatory

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setae while the third has only a rudimentary exopod. The dactyls of the third maxillipede and pereiopods are short and claw-like, a character considered to be common in many scyllarid phyllosomas. A coxal spine with an accessory seta at its base is present in the third maxillipede and the pereiopods. The abdomen is 0.16 mm. in length with almost parallel sides. It is nearly half the length of the hind-body. The details regarding the spines and setae at the end of the abdomen are shown in Fig. 1-E.

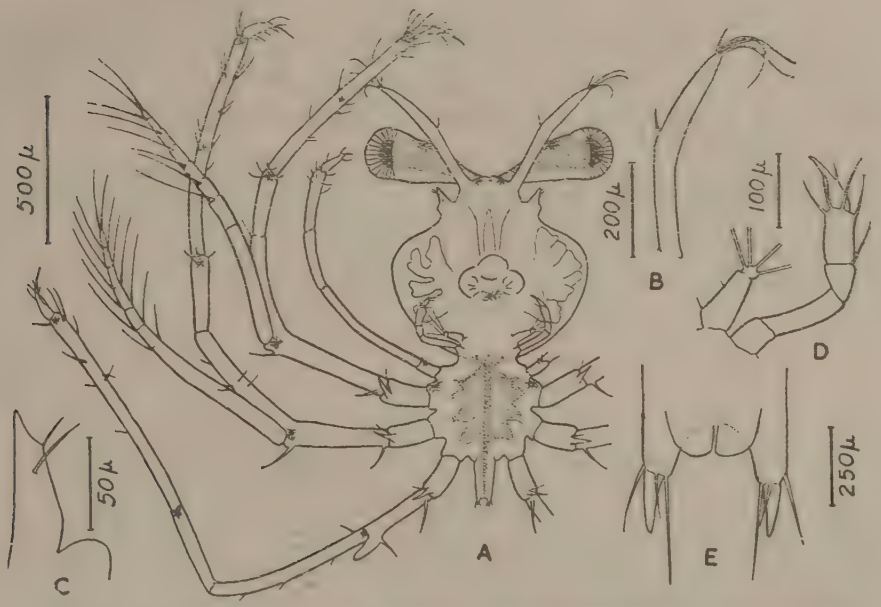

FIG. 1. A. First phyllosoma of *S. sordidus*. The chromatophores are indicated as black stellate markings. B. First antenna. C. Second antenna. D. Second maxilla and second maxillipede. E. Tip of the abdomen.

It may be pointed out here that the first phyllosoma of *S. sordidus* bears some general resemblance, especially the general shape of the larva, the distribution of the chromatophores on the body and the development of the appendages, to the one described by the authors earlier (1957, p. 58, Fig. 6) and considered at that time as probably belonging to *S. orientalis*. However, these two larvae differ in many respects. The first phyllosoma of *S. sordidus* is noticeably smaller in size but the abdomen is relatively long, the one in the earlier larva being less than one-third the hind-body. The structure of the second antenna is strikingly different and minor differences in the number and nature of the spines and setae at the end of the abdomen could also be made out.

Although the adults of *S. sordidus* seem common in the neighbourhood of Mandapam, their larvae are relatively rare in the routine plankton collections made in this area while the other type is more common. In view of the similarities in the two larvae the authors at first thought that the 1.35 mm. larva described in 1957

might actually be the second phyllosoma stage of the same species. But a comparison of the development of the various appendages in these two types shows the greater possibility of both these belonging to the first stage of two different species unless the first larva of *S. sordidus* described here moults in a very short time after hatching, effecting an increase in size without changes in other characters. Attempts are being made to rear these larvae which will help in deciding the issue and until then the authors are inclined to consider the two types as distinct.

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INSTANCES OF EXCESSIVE THICKENING OF CERTAIN BONES IN THE RIBBON FISH, *TRICHIURUS LEPTURUS* LINNAEUS*

By P. S. B. R. James

Central Marine Fisheries Research Station, Mandapam Camp.

Introduction

While studying the biology and fishery of ribbon fishes of the family Trichiuridae from Indian waters, my attention was drawn by Dr. S. Jones to the occurrence of some swollen bones, popularly called 'stones' in *Trichiurus lepturus*. Although Cuvier (*vide* Gunther, 1860) and Starks (1911) have mentioned such instances in the skull and clavicle of this species, similar cases in respect of other bones have hitherto not been reported. The results of an investigation of the identity, nature and occurrence of these bones are presented in this paper.

Material and Methods

Several samples of *Trichiurus lepturus* (*Trichiurus haumela* (Forskål)) from various places, especially where it forms an important fishery, along the East and West Coasts of India were collected during the period January 1959 to July 1960. 534 specimens of both sexes and of different sizes, varying between 43 to 978 mm. (S.L.) were examined for the extra ossified bones. Besides these, samples of three other species of ribbon fishes occurring in Indian waters namely *Lepturacanthus savala*, *Eupleurogrammus intermedius* and *Eulpleurogrammus muticus* (James, 1960) were also examined, to ascertain any such instances of excessive thickening of bones. Alizarin stained specimens of the four species were studied to fix the identity of bones that become stone-like and to study the effect of such extra growths on the adjoining structures. Skeletons of fresh specimens were prepared by cooking in water and the disarticulated parts were scrutinized for additional ossifications. In addition to material from Indian coastal waters, four large specimens of *T. lepturus* from the Andaman Sea were also examined.

Observations

General considerations: Excess ossification, or additional bone formation is confined to the supraoccipital bone and the interneural and interhaemal spines. Table I shows a summary of the material examined and results obtained.

Of the four species of ribbon fishes occurring in Indian waters, thickened bones appear to be present only in *T. lepturus* and its occurrence was found to be fairly

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common. Of those affected, males with such bones are less numerous (36.5%) than the females (63.4%). Thickening of supraoccipital and the interhaemal spines is more common while that of interneurals appears to be comparatively rare. Occasionally all the three types are found in the same individual, or a combination of any two may be present. The thickened interneurals and interhaemals may be successive, alternating or even widely separated by intervening normal spines. The successive bones may or may not unite, but when they unite, they form a single massive ' stone '. The number of such modified bones forming a mass or ' stone ' can be made out by counting the number of corresponding neural or haemal spines. The affected neural or haemal spines are slightly short and blunt at their extremities, whereas the normal ones are longer and pointed at their tips. As in the case of normal bones, the enlarged bones are covered by a layer of muscles, and externally by the skin.

The bony enlargements are clearly perceptible externally in the bigger size groups but are not always symmetrical and often are seen prominently bulging on one side. In smaller individuals their presence can be detected by touch. The enlarged bones (Pl. II, Fig. 3) are of various shapes : oblong, oval, triangular, round or even irregular but are usually compressed laterally in conformity with the lateral flattening of body. Sometimes a single ' stone ' presents a groove or depression to give it a bilobed appearance and when it is a compound structure involving more than one spine, intervening depressions indicate the number of such spines.

The swollen bones fully occupy the interspaces between the preceding and succeeding bones, often bringing pressure on normal bones to bend or curve round the enlargements (Pl. I, Figs. 3, 4). Longitudinal sections of the three types of enlarged bones Pl. II, Fig. 3) have been examined. The thickened supraoccipital presents a honeycomb-like pattern in a section. The bony substance is soft and alveolar. The thickened interneural or interhaemal is less alveolar and often presents a bigger central cavity, whose bony substance is harder than that of supraoccipital. In all cases, it appears, the bone deposition is more of a superficial, soft, cellular nature than a regular periosteal deposit. The more alveolar bones float, while their normal counterparts sink in water, showing that this modification tends to make the bones buoyant.

In the normal head of a specimen, the posterior confluence of the frontal ridges, and in continuation of it, the low supraoccipital crest are elevated to form a sagittal crest, which is confined to the nape (Pl. I, Fig. 1). When there is an enormous thickening of the supraoccipital bone the whole occipital region of the skull is dorsally concealed by the bony mass, sometimes extending to the first one or two vertebrae, and results in a further elevation and strong convex dorsal curvature at the nape region (Pl. I, Fig. 2). In such specimens the pre-occipital profile of the head steeply dips down. The varying degree of enlargement of supraoccipital fully or partially overlaps the parietals and the temporal ridges on the sides. The supraoccipital enlargement is occasionally asymmetrical at the forked posterior end. It bears a median groove along the posterior half, which indicates the position of the origin of dorsal fin.

The interneural thickenings are much larger than the interhaemal. This is probably a direct result of the greater height of the interneurals. The interhaemal thickenings appear never to exceed the height of the body between the lateral line (running along lower one-third of body) and the ventral margin of the body.

TABLE I

Summary of the data

(Expressed in percentages)

Total number of specimens examined	Total number showing bone enlargements	Occurrence of bone enlargements	Supraoccipital enlargement alone	Interhaemal enlargement alone	Interneural enlargement alone	Supraoccipital, Interhaemal together	Supraoccipital, Interneural together	Interhaemal, Interneural together	Supraoccipital, Interhaemal and Interneural
534	56*	10.4	26.9	28.5	1.6	44.6	12.5	10.7	7.1
Males	19	36.5	14.2	25.0	100	40.0	42.8	50.0	50.0
Females	33	63.4	85.8	75.0	Nil	60.0	57.2	50.0	50.0

* 4 Specimens, sex unknown, not included in calculation of percentage sexwise.

Analysis of frequency of occurrence.—From Table I, and other data presented in the text, the following observations are made :—

The supraoccipital thickening (Pl. II, Figs. 1 and 2) was found to be present in both sexes. Its occurrence was first noticed in a specimen measuring 422 mm. from Vizhingam (Trivandrum) on the West Coast. The biggest specimen showing this enlargement was 707 mm. from Idinthakarai (Tinnevelly) on the Gulf of Mannar. However, a 978 mm. (male) was found with a normal supraoccipital bone. The supraoccipital thickening occurs either exclusively or in combination with enlargements of interhaemal or interneural or both. Of 56 specimens showing different combinations of the three types, supraoccipital enlargement is present in 41 specimens as under :—(i) supraoccipital alone—14 (2 males, 12 females, ranging in size between 424-790 mm.) ; (ii) in combination with interneural enlargements—6 ; (iii) with interhaemal enlargements—21 ; (iv) with both interhaemal and interneural—4. Sexwise, it is distributed in the ratio of 13 males to 24 females (+4 of sex unknown).

Interhaemal enlargement (Pl. I, Fig. 3) was first noticed in a specimen of 422 mm. and the biggest specimen measures 728 mm., both from Vizhingam (Trivandrum). It was found in 39 individuals as follows :—(i) exclusively—12 ; (ii) with supraoccipital—25 ; (iii) with interneural—6. The sex ratio for the occurrence of enlarged interhaemal is 15 males to 20 females (+4 of sex unknown).

The interneural enlargement (Pl. I, Fig. 4) was first noticed in a specimen of 523 mm. and the biggest specimen in which it occurs, measures 978 mm., both from Vizhingam (Trivandrum). Its occurrence in 10 individuals is as follows :—(i) exclusively in 1 ; (ii) with supraoccipital—7 ; (iii) with interhaemal—6. Sexwise, it is present in 5 males and 4 females (+1 of sex unknown).

It will be seen that interhaemal enlargements are more common than those of the interneurals. The location of the thickened bones is variable. The anteriormost interhaemal enlargement was found to be that against the 56th vertebra and the posteriormost against the 112th vertebra from anterior end, inclusive of atlas vertebra. In the case of interneural thickenings the anteriormost was found against

vertebra 15, and the posteriormost against vertebra 88. This indicates that any interneural or interhaemal bone is equally susceptible to enlargement, although in the material examined, they fall within the limits mentioned above.

The fusion of the thickened bones is common on the haemal side, and except for one instance, it is absent on the neural side. The maximum number of ' stones ' found in a single individual at a time is 5. The biggest ' stone ', a compound interneural condition involving 3 spines, measures 23.5 mm. in height and 22.5 mm. in width.

Discussion and Conclusions

Excess ossification of bones is not uncommon in fishes, and many earlier workers have drawn attention to this phenomenon, in the different groups. Barnard (1948) refers to such thickened bones in *Chrysoblephus gibbiceps* and *Caranx equula* and terms the condition as ' hyperostosis.' Ebina (1936) mentions extraordinary bone formation in the supraoccipital bone of *Evynnis cardinalis*. Gopinath (1951) described the secondary ossification of supraoccipital crest in certain Carangids, and suggested such bone formation helps the fishes to maintain equilibrium. Gregory (1933) mentioned the swelling of the supraoccipital in *Chaetodipterus faber* and Gunther (1860) mentioned the development of outgrowths from certain of the interneurals and neurals of *Lepidopus caudatus* which is known to be a teratological condition. Kestevan (1928) and Lütken (1880) as cited by Gopinath (*l.c.*) have described an occipital knob in the crest of *Pagrosomus auratus* and the large occipital crest which brings in a change in the head profile of *Coryphaena hippurus*, respectively.

All the above authors, except Gunther's reference to *Lepidopus*, have referred to excess ossification of the supraoccipital or its crest in a variety of fishes, while other bones appear evidently not to be involved. The present observations on *Trichiurus lepturus* draw attention to an additional ossification not only of the supraoccipital bone, but also the interneural and interhaemal spines and their combinations. Cuvier was the first to notice a thick mass of bone formed by the fusion of supraoccipital and parietals in the skull of *T. lepturus* and considers it as a peculiarity of the species. Gunther (*l.c.*) while describing the skull of the same species remarks that such a condition was not noticed by him. According to him, it could possibly be a disease of bones similar to that he noticed in *Lepidopus caudatus*.

Starks (*l.c.*) refers to thickening of bones in the skull and clavicle of two specimens of *T. lepturus* from the Atlantic. In addition, he found the lower part of the clavicle swollen, which evidently is a rare condition, in one specimen from China, labeled *Trachiurus japonicus* in the collection of Stanford University. He, however, stated that there are no swollen interneurals, in his account of the general osteological characters of the genus *Trichiurus*.

The present observations show that enlargement of supra-occipital bone, and the interneural and interhaemal spines is quite common in *T. lepturus*, from different localities along the Indian Coast. Individuals over 422 mm. only show the supra-occipital bone and interhaemal spine thickening, whereas the interneural thickening seems to be present only in specimens above 523 mm. Although the analysis of the sample shows a greater percentage of females with these enlarged bones, statistical analysis of data applying the test of significance at 5% level has shown that sex is independent of the condition. It may, therefore, be concluded that the three

types of thickened bones occur in individuals quite at random, and irrespective of age (above the size limits given), sex and locality.

While enlargement of these bones is common in *T. lepturus*, it is significant that not a single instance of this is revealed in an examination of several specimens of allied species of the family Trichiuridae from Indian waters, all of which have almost similar habits, external form and general osteological characters. Cuvier's description that this thickening and union of bones is a pecularity of the species is not inconceivable from the present observations, while provision is also made to Gunther's contention that it could be a disease of bones*. It may safely be stated, whatever be the cause of excess ossification in this species, its ouccurrence is confined only to *T. lepturus*, and not noticed in 600 specimens of *L. savala*, 3038 specimens of *E. intermedius* and 450 specimens of *E. muticus*, examined for this purpose.

It is interesting to note, in this connection, bone thickening in *T. lepturus* has been reported from Atlantic and China (Starks, *l.c.*) and attention is drawn to its occurrence in the same species now, from Indian waters and Andaman sea, thus throwing more light on the homogeneity of the species *Trichiurus lepturus* both in the Atlantic and Indo-Pacific.

Summary

Excess ossification of the supraoccipital bone, interhaemal and interneural spines of *Trichiurus lepturus* is described.

Of the four species of ribbon fishes from Indian waters, it appears to occur only in this species, in both sexes and from all localities.

The theory of homogeneity of the species, *T. lepturus* in Atlantic and Indo-Pacific is supported by the present observations.

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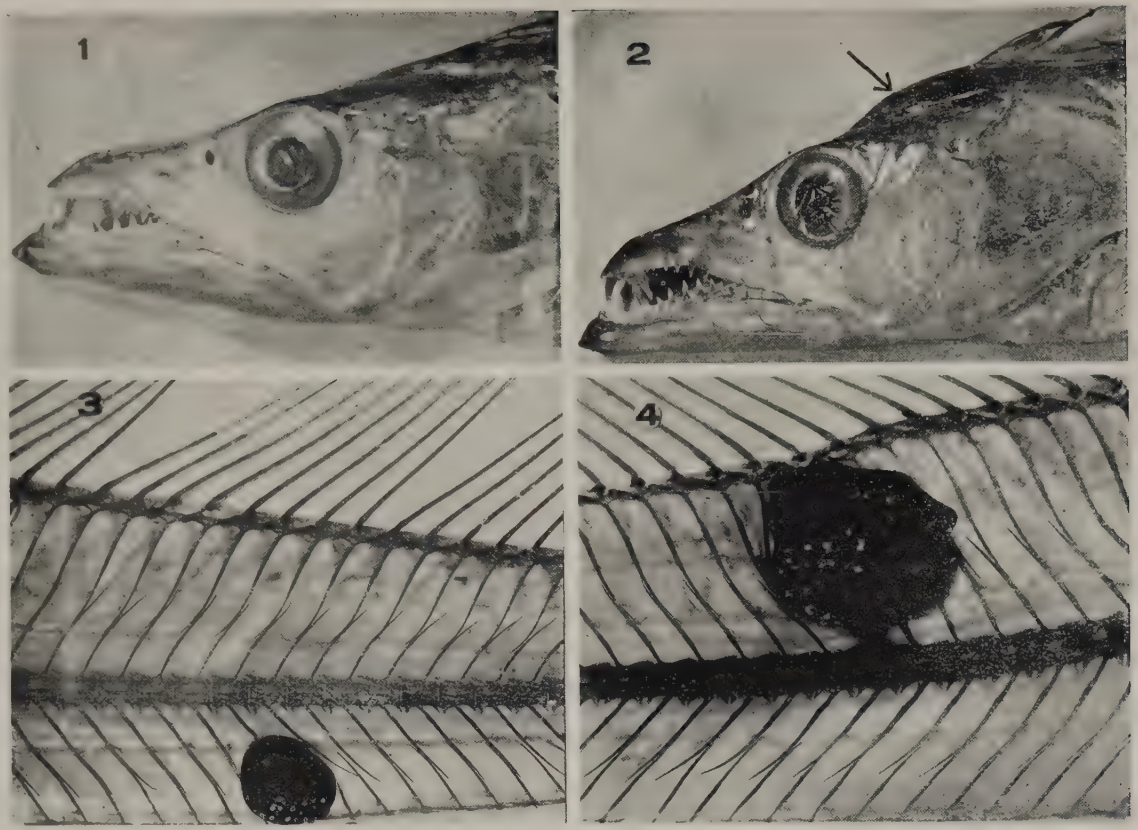


Plate I

Fig. 1. Head (10 cm.) of specimen with snout-vent length 24.5 cm. Usual curvature at nape. 2. Head (9.5 cm.) of specimen with snout-vent length 22.5 cm. Arrow indicates unusual curvature at nape, due to bone thickening. 3. Thickened interhaemal spine in specimen of 72.8 cm. S.L. 4. Thickened interneurals (fused condition) in specimen of 100 cm. S.L. Anterior end to the right side.

Plate II

Fig. 1. Dorsal view of skull showing thickening of supraoccipital bone (*b*) in a specimen of 89.5 cm. S.L., head length 13.35 cm. 2. Lateral view of the same. 3. Isolated bones. (*a*) Normal supraoccipital bone (57.4 cm. S.L.); (*b*) Ossified supraoccipital (68 cm. S.L.); (*c*) Longitudinal section of extraossified supraoccipital showing honey-comb pattern. (*d*) normal interneural (57.4 cm. S.L.); (*e*) Ossified interneural (70.7 cm. S.L.); (*f*) Longitudinal section of ossified interneural (70.7 cm. S.L.); (*g*) Normal interhaemal (57.4 cm. S.L.); (*h*) Ossified interhaemal (70 cm. S.L.); (*i*) Longitudinal section of ossified interhaemal (58.5 cm. S.L.); (*j*) Two successive interhaemals ossified and on way to coalescence (63.7 cm. S.L.); (*k*) Ossified interhaemal, entire length (59.2 cm. S.L.).

J. Mar. biol. Ass. India, 1960, **2** (2) : 259-262

MARINE BIOLOGICAL AND OCEANOGRAPHIC INSTITUTIONS OF THE WORLD

IV. THE NAPLES ZOOLOGICAL STATION

By Andrew Packard

Assistant to the Zoology Department, Stazione Zoologica, Napoli

Founded in 1872 the Naples Zoological Station on the Mediterranean coast of Italy is one of the oldest marine biological stations in the world. Moreover it is one which has maintained its purpose unchanged from its inception : namely to provide the facilities for visiting research workers of different countries throughout the world to study the zoology and the physiology of the fauna and flora of the Bay of Naples. It does this with the aid of a professional staff of ten and technical personnel of 60, housed in a single building that lies in the center of the Naples' municipal park known as the Villa Communale. The original 3-storey building fronted directly onto the beach with the whole of its ground floor taken up by a public aquarium—the famous Naples Aquarium of the tourist guides—and with research laboratories in the upper two floors. Around the end of the century two further blocks in the same style had been built on either side of the first and the Stazione Zoologica now presents a continuous front 110 yards long facing out across the Bay to Capri and the Sorrento coast : the Physiology department at the east end, Aquarium, Administration, Botany and general services in the center, and the Zoology Department at the west end. Between Physiology and Administration there is an entrance courtyard decorated by vines and Whistaria and a small fountain above which a bronze plaque portrays the founder of the Institute, Anton Dohrn. Between the center block and Zoology is the new library built in 1957. Internal reconstruction in the Institute bulding has allowed four floors instead of three, and the upper floors of the Administration block now contain new laboratories and a dining hall for the ' Mensa ' and the rehoused reference museum. A mile to the west of the Station, in the small harbour of Mergellina, the station keeps its boats : the ' Cavolini,' ' Raffaele ' and the larger ' Rinaldo Dohrn ' launched in 1960, as well as a number of smaller collecting boats.

The Zoological Station is administered by a Committee of Management responsible to the Ministry of Public Instruction in Rome with Peter Dohrn (grandson of the founder and son of the previous director, Reinhard Dohrn) as Director. It operates (1960-61) on a total income of about £100,000 derived from a variety of sources. Italy supports the Station to an extent of 30% of the budget and 10% comes from admission fees to the Aquarium and the sale of biological specimens : the rest is from international payments, the most important being in the form of ' Table ' rent.

The ' Table ' system explains the individual characteristics of the Naples Zoological Station better than any other single feature : it was the brilliant idea of the founder by which he hoped to encourage Scientists from all over the world to profit from the exceptionally rich fauna and flora and favourable climatic conditions of the Naples region and at the same time to assure a continuous income for research. By a ' Table ' is meant the research space and facilities for one biological worker,

and a ' Table fee ' is intended to cover the cost to the station of maintaining one scientist at work in the station. Just as some hospitals in India have ' beds ' paid for by private individuals which insures them full medical attention there if necessary, so foreign governments, and independent institutions such as Universities, Academies and Research Councils, pay table fees to the Zoological Station which give graduate scientists from the different countries and institutions the right to come to Naples to do their research work. The concept of the Tables has been extended, so that now a number of the larger grant-paying organizations—Rockefeller Fund, U.S. Office of Naval Research, and U.S. National Science Foundation—also act as table holders. A biologist from a country which does not have its own table, but applying to work at the Naples Zoological Station, has therefore the opportunity of being accepted as a guest when vacancies exist. The full yearly fee for a Table is now $3,000 (£1,000). The sum does not include salaries or travelling expenses of the table holders, but entitles them to all they may require to carry out their particular piece of research. One guest worker may come for the full year, or a number of guests may come for part of the year only : for instance, the University College of London table is regularly occupied by six people coming for two months. At present there are 60 tables which are listed below. It will be noticed that India has no table, although many Indians have visited the station and one or two have worked here.

Belgium :	Ministère de l' Instruction Publique, Brussels ..	1
Denmark :	Ministry for Public Instruction, Copenhagen ..	1
France :	College de France, Paris ..	1
Germany :	Deutsche Forschungsgemeinschaft, Bad Godesberg ..	3
	Deutsche Akademie d. Wissenschaften, Berlin ..	1
	Staatssekretariat f. d. Hochschulwesen, Berlin ..	2
	Kultusministerium Nordrhein-Westfalen, Düsseldorf ..	1
	Max-Planck-Gesellschaft, Göttingen ..	4
	Kultusministerium Niedersachsen-Schleswig Holst. ..	1
	Hochschule, Hamburg ..	1
	Ministerium f. Unterricht u. Kultur, Mainz, u. ..	
	Min. f. Erziehung u. Volksbildung, Wiesbaden ..	1
	Bayerische Staatsmin. f. Unterricht u. Kultus Munschen ..	1
	Kultusmin. Baden-Württemberg, Stuttgart ..	1
Great Britain :	University of Cambridge ..	1
	University of Oxford ..	1
	University of London ..	1
	Universities of St. Andrews and Birmingham, Brit. Ass. for t. Advancement of Science ..	1
	Royal Society, London ..	1
Israel :	Comunita Israelitiche Italiane, Roma ..	1
Italy :	Ministero Publica Istruzione, Roma ..	8
	Consiglio Nazionale delle Ricerche, Roma ..	6
	Provincia di Napoli, Napoli ..	3
	Azienda di Cura, Soggiorno e Turismo, Napoli ..	2
	Istituto di Biologia, Università di Perugia ..	1
	Ente per il Turismo, Napoli ..	1
	Fondazione A. & R. Dohrn, Nopoli ..	2
Japan :	Ministry of Public Instruction, Tokyo ..	1
Netherlands :	Kon. Akademie van Wetenschappen, Amsterdam ..	1

Sweden:	Kungl. Svenska Vetenskaps-Akademien, Stockholm	.. 1
	Statens Naturvetensk. Forskningsråd, Brämma	.. 2
Switzerland:	Department des Innern, Bonn	.. 1
U.S.A.	National Science Foundation, Washington	.. 4
	U. S. Air Force	.. 1
N.A.T.O.		.. 1
		60

On arrival at the Zoological Station a guest worker is provided with a laboratory : if he is a systematist, histologist, ecologist or other zoological worker this room will be in the Zoological department, where, in addition to glassware, microscopes and reagents he can ask for any other special items of equipment from fixing and embedding materials for electron microscopic work to small aquaria built to his own specifications. In addition there is a range of constant temperature rooms and a general laboratory equipped with standard microtomes as well as cryostat, pH meters, electric balances and other items.

If the guest is a physiologist, biochemist, radiobiologist or cytochemist, in addition to his own room he will have the use of the general laboratories. There are several of these, respectively for general chemistry, centrifugation, spectrophotometry, chromatography, radioisotope work, electrophysiology and microrespirometry. The institute possesses up-to-date apparatus for these and other routine biological activities. In both Zoology and Physiology Departments there is running sea water from a partially closed system separate from the main Aquarium supply.

Each guest is given 12 library cards, each with a number, that allow him to borrow from the library any 12 books at one time with a minimum of complication and time. The library, which has been collecting biological reprints bound in volumes since the latter half of the last century has 45,000 volumes housed in some 3 miles of shelving and is one of the most complete of its kind. The reading room displays current and unbound numbers of 500 periodicals.

During the morning of each working day guests are asked what living material they require from the sea, and on the basis of these requests orders are compiled for the next morning's fishing, the material being brought to the station and distributed by midday. The station employs a staff of 10 fishermen trained to locate and recognize all the common and less common species, both animal and plant, found in the plankton, in dredges, and along the shores of the Bay of Naples : a fulltime diver is included, Guests may themselves go to sea on the Station's boats, either as observers or to do their own oceanographic or ecological work. The 'Rinaldo Dohrn' is being set up with additional recording apparatus for oceanographic work not previously possible with the smaller vessels.

A midday meal is provided—traditionally held at one table, the Mensa—at which guests have a chance to get to know those doing research in fields other than their own. There is also a small kitchen where guest workers may cook in the evenings. Living accommodation is not provided by the Station but the secretary's office is able to help in finding this. The Zoological Station is open throughout the year. Collecting and other activities requiring a full staff being continued uninterrupted except for public holidays : the doors of the Station are attended at all

times so that people working in the institute may come and go at any time in the 24 hours.

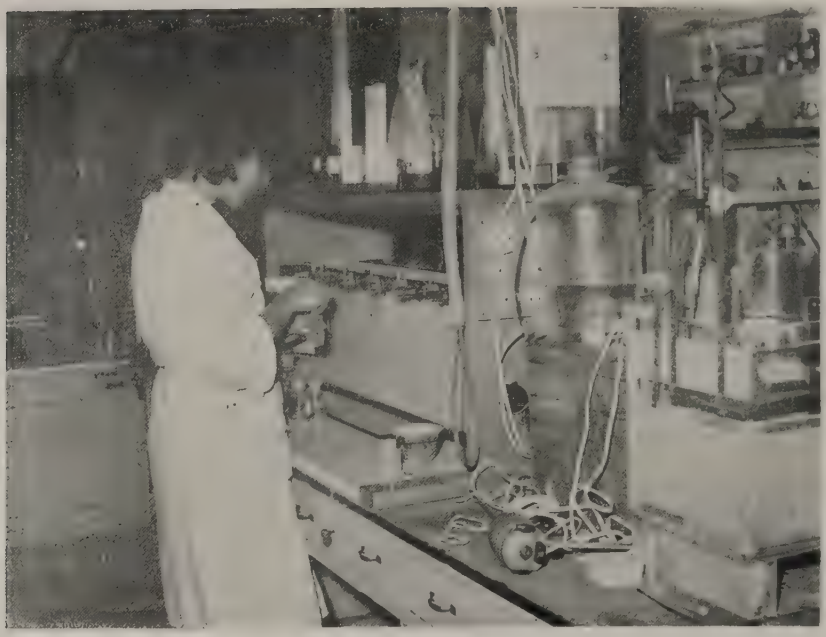
Theoretically the research at the Naples Zoological Station is as heterogeneous as the international complement of its visiting research workers and as varied as its facilities permit. In practice the influence of a number of biologists who have returned year after year and the presence of a small permanent staff of scientists having their own programme, together with certain exceptionally favourable features of the marine environment, have resulted in the development of a number of 'schools' of research. Work on the biochemistry of development and identification of new enzyme systems is carried on throughout the year on sea urchin eggs of the genus *Paracentrotus* and *Sphaerechinus*. A school of behaviour concerned with the relationship of brain and sense organ structure to learning is centered round the common octopus, *Octopus vulgaris*. The preparation of a monograph on the order *Hydroidea* brings together hydroid specialists from all over the world to study their systematics, life history, ecology and regeneration. Through its convenience as a scientific institute situated on the edge of the Bay of Naples the Zoological Station has been used for research in marine geology.

The Station undertakes no regular teaching, but from time to time conferences and symposia are held. In 1961 there will be a symposium on Mediterranean Shore Ecology. The Station publishes the *Pubblicazioni della Stazione Zoologica di Napoli* and the *Faunae Flora del Golfo di Napoli* : a definitive monograph series of which the two volumes on the *Hydroidea* will be number 39.

Visitors are welcome at the Station and further information can be obtained by writing to the Director, Dr. P. Dohrn, Stazione Zoologica, Napoli, Italy.

1. A general view of the Naples Zoological Station, Italy.

2. Part of the main library.



3 & 4. Different views of the laboratories, Naples Zoological Station.

NOTES

'OBSERVATIONS ON SOME PELAGIC TUNICATES IN COASTAL WATERS OF THE BAY OF BENGAL'

The pelagic salp, *Salpa* (*Iasis*) *zonaria* (Pallas) was so abundant off the River Mahanadi (Orissa) in 40-42 metres over mud grounds during late February and whole of March 1960, that individuals choked the trawl meshes. The salps could be observed just under the surface, and as far down as the eye could penetrate the water-mass, in immense numbers. This 'swarm' was approximately 3 miles in length and one mile across, oriented parallel to the coast. Weather conditions were calm, and the water was extremely clear.

A size-range between 12 and 30 mm. was noted, with the majority over 20 mm. Individuals over 20 mm. showed 'budding'. Three specimens, 22, 28 and 30 mm. respectively, were found eviscerated and their empty 'tests' were occupied by the pelagic amphipod *Phronima sedentaria* (Forskäl).

Also taken in late February 1960, was a specimen of *Pyrosoma atlanticum* (Peron) off False Point (Orissa). This pyrosome was taken during a haul made in 114-158 m., and there can be no doubt that it was retained accidentally (being jammed among fish also taken at the same time) by the trawl used, the cod end mesh being 77 mm.; thus, it is possible that this pyrosome might have been more common in the area than present data would suggest.

The specimen measured 110 mm. in length; it was 15 mm. wide at its narrow, and 25 mm. wide at its broader end.

The present data are of some interest in that it extends distribution pyrosomes into the Bay of Bengal. Sewell (1913) had previously recorded 4 *Pyrosoma* (species not mentioned) in about 800 m. off Ceylon (7° 26′ 6″ N ; 85° 7′ 15″ E).

Details of the taxonomy and distribution of *S. zonaria* and *P. atlanticum* are given by Berrill (1950) and Sewell (1953). The latter author indicates that *P. atlanticum* is most common at some depth below the surface, rather than at the surface; and the former remarks that these forms do not normally occur in coastal waters except where the continental slope approaches the shore-line, or when unusual invasions of the continental shelf by outlying water takes place. The present data come from around 20° 02′ N ; 86° 59′ E, where the continental shelf is fairly broad; and there is therefore, an indication that an invasion by outlying water might have occurred over the continental shelf in that region. Such a type of invasion is known to occur about 300 miles south of this location, near Visakhapatnam (La Fond, 1954).

I am thankful to Shri P. V. Bhavanarayana, Lecturer, Zoology Department, Andhra University, Waltair, for confirming the identity of both these tunicates.

Central Marine Fisheries Research Unit,
C/o Andhra University,
Waltair, A.P.

A. K. NAGABHUSHANAM.

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COSSURA DELTA REISH (POLYCHAETA) FROM THE VELLAR ESTUARY

In the course of a series of dredgings that were made in the Vellar estuary to study the bottom fauna, a Cirratulid, *Cossura delta* Reish (1958) was obtained in two localities which may be referred to as Stations C and D (Jacob and Rangarajan, 1959). The genus *Cossura* comprising four species *Cossura longocirrata* Web. & Ben. (1887), *C. candida* Hartman (1955), *C. pygodactyla* Jones (1956) and *C. delta* Reish (1958) occurs mostly in America. *C. longocirrata* alone has been reported from Denmark (Eliason, 1920 and Thulin, 1921) and North Atlantic (Wesenberg-Lund, 1950). Now *C. delta* Reish is reported for the first time in Indian waters.

Family : CIRRATULIDAE

Genus : *Cossura* Webster & Benedict.

Cossura delta Reish.

The body is cylindrical and rolls up into coils posteriorly. The length varies from 15 mm. to 20 mm. and the diameter from 0.5 mm. to 0.6 mm. There are about 100 segments and the intersegmental lines are very faint in the anterior end. In life the animal is pale red in colour. The prostomium is conical in shape and devoid of tentacles and palps. It is slightly longer than width. Eyes are absent. In some of the specimens the prostomium is everted and showed 15-20 digitate subequal lobes. The peristomium lacks setae. The first setigerous segment follows the peristomium. A very long slender annulated median tentacle arises dorsally between the second and third setigerous segments in well narcotised specimens preserved in alcohol. In worms picked up from the seiving and preserved immediately in 4% formalin the dorsal tentacle is seen to arise from the posterior end of the second setigerous segment. The length of the tentacle varies from one-half to two-thirds of the length of the body.

Dorsal cirri, ventral cirri and gills are totally absent. Setae are simple curved capillaries and occur in two bundles which issue directly from the body wall without any parapodial lobes. The first setigerous segment is uniramous and the rest are biramous in the anterior end. The bundles of dorsal and ventral setae are close to each other forming as nearly a continuous series as in *C. candida* (Hartman, 1955). They also show a biserial arrangement as in *C. candida* with a row of long capillaries followed by another row of short capillaries. From the second to twenty-fifth segment there are usually 6 to 8 pairs of capillaries in the dorsal and ventral bundles. After the twenty-fifth segment the number of setae diminishes, and beyond the fortieth segment the dorsal bundle has 3 to 5 long straight smooth unbordered

capillaries, whereas ventrally 3 to 4 curved, unbordered capillaries are present. Further posteriorly in the body the segments show a slight increase in the setae. A few of the pre-anal segments are devoid of setae. The curved and straight capillaries are spinous along the outer edge. The body is flattened dorsoventrally upto thirtieth segment, and the segments thereafter are cylindrical and not clearly distinguishable excepting the last few. The anal segment is truncated with two small lateral cirri.

C. delta which has been described by Reish and the specimens from Vellar estuary agree (1) in the presence of a single achaetous segment anteriorly, (2) in having curved limbate setae in the anterior segments and (3) in having the median tentacle arising from the third setigerous segment. The specimens from the Vellar estuary differ from Reish's description in having the first setigerous segment uniramous and also in not having the notopodial and neuropodial regions distinctly separate. Reish (1958) has not described the posterior end of the body, all the specimens collected by him being incomplete specimens. The anal region in the Vellar specimens differs from that in the other three species in having two small lateral cirri.

C. delta occurs in a limited locality in the Vellar estuary at a depth of 6 to 12 feet. The specimens were dredged when the salinity was from 22.64‰ to 32.46‰ at the bottom. The animals live in slimy mud tubes in clayey silt bottoms.

My thanks are due to Dr. Eve C. Southward and Dr. F. Rullier for help in identifying the Polychaete. I thank Dr. Olga Hartman for helpful criticisms and suggestions in preparing this note. My thanks are due to Prof. R. V. Seshaiya for guidance and to Dr. Vijayaraghavan and Dr. Jacob for their interest and encouragement, and to the Ministry of Education for the award of a Research Scholarship.

Marine Biological Station,
Porto Novo.

K. BALASUBRAHMANYAN.

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ON THE OCCURRENCE OF THE PLATACID FISH *TRIPTERODON ORBIS* PLAYFAIR IN INDIAN WATERS

On 20-12-'60 at the fish landing centre at Kuntakkal point on Rameswaram Island facing the Gulf of Mannar two platacid fishes were noticed among specimens of *Drepane punctata* (Linnaeus), and *Ephippus orbis* (Bloch). One of these was brought to the Laboratory at the Central Marine Fisheries Research Station, Mandapam Camp and was identified as *Tripterodon orbis* Playfair hitherto known from the South African Coast from Natal to Mombasa (Smith, 1949) and Madagascar (Fourmanoir, 1957). The specimen which measures 116 mm. in standard length is a juvenile, the adult of which is known to attain 762 mm. and weigh about 20 lbs.

Subsequently I have come across two specimens of this species, 101 mm. (locality unknown, probably Gulf of Mannar) and 125 mm. (from Dhanuskodi ; Gulf of Mannar) of standard length, in the reserve collection of Central Marine Fisheries Research Station Museum and a brief description of these three specimens is given below.

Tripterodon orbis Playfair

Tripterodon orbis Playfair, 1866. *in* Playfair R.L. and Günther A.C.L., *The Fishes of Zanzibar*, p. 42, pl. 7 fig. 1 ; Smith J. L. B. 1936. *Trans. roy. Soc. S.A.*, **23** : 303 ; 1953. *The Sea Fishes of Southern Africa*, 233, and pl. 29, fig. 578. (see for other references) ; Fourmanoir. P., 1957. *Mem. Inst. Scient. Madagascar*, I, (Ser. F) p. 40.

D. IX ; 20-21 ; P_1 ii, 17 ; P_2. I, 5 ; A. III, i, 15-16 ; C. i, 15, i.

Head 34.5 to 35.6 ; eye 10.8 to 11.2 ; snout 19.2 to 19.8 ; interorbital distance 11.5 to 11.9 ; distance from snout to posterior nostril 13.2 to 13.9 ; first predorsal distance 60.3 to 64.8 ; second predorsal distance 84.5 to 88 ; prepectoral distance 31.9 to 34.7 ; prepelvic distance 36 to 38.6 ; preanal distance 68.4 to 69.4 ; base of spinous dorsal 30.7 to 37.6 ; base of soft dorsal 44.6 to 46.4 ; base of anal 38.8 to 39.6 ; length of longest (third) spine 51.5 to 62.9 ; height of second dorsal 25.7 to 28 ; length of pectoral 22.3 to 23.2 ; length of pelvic 34.2 to 36 ; length of anal 26.8 to 32.2 ; length of caudal 32.5 to 35.6 ; and depth of body 75.7 to 79.3 percent in standard length.

Mouth slightly protractile, preopercle and opercle scaled. Teeth tricuspid in regularly arranged rows in both jaws. Gill rakers 10, minute ; pectoral short ; outer ray of pelvic prolonged, tip surpassing anal origin ; caudal slightly lunate.

Eight conspicuous vertical dark bands and other colour characteristics in general tally with the plate figure 578 given by Smith (1949).

Distribution : Natal to Mombasa along South African Coast, and Madagascar. The present record extends the distribution of the species to Rameswaram Island, Gulf of Mannar, Indian Ocean.

All the three specimens are deposited in the Central Marine Fisheries Research Station Museum, Mandapam Camp.

My thanks are due to Dr. E. G. Silas for suggestions and help.

C/o Central Marine Fisheries Research Station, Mandapam Camp. A. Indrasenan

FURTHER NOTES ON *SPRATELLOIDES DELICATULUS* (BENNETT) AS A TUNA LIVE-BAIT FISH WITH A RECORD OF *S. JAPONICUS* (HOUTTUYN) FROM THE LACCADIVE SEA

In a previous note (Jones, 1960) mention was made of the collection of *Spratelloides delicatulus* (Bennett) from the vicinity of Bitra and Agathi in the Laccadive Archipelago recording for the first time its occurrence in Indian waters. Also in view of its shoaling behaviour and the habit of getting attracted to light the possibility of its utilization as a live-bait for the oceanic skipjack, *Katsuwonus pelamis* (Linnaeus) was indicated.

Subsequently the fish was collected from the lagoons and reefs around Minicoy, Chetlet and Kiltan, in the Laccadives showing its wide distribution in the Laccadive Sea. The language in the nine of the ten inhabited islands is Malayalam and here the fish is known as *choorai-chala* meaning tuna sardine (*choorai*=tuna ; *chala*=sardine). The local name is significant being self-explanatory, clearly indicating that the inhabitants are aware of the predilection of tuna towards it as food. On enquiry it was reported that the tuna follow shoals of *S. delicatulus* and feed voraciously on them in certain seasons especially during the south-west monsoon. It is reported to enter the lagoons in large numbers when it is caught by the local people for their consumption. In the island of Minicoy where Mahl dialect is spoken this fish is known as *rahi* and is used as a bait fish whenever available. It is reported to enter the lagoon just before the monsoon period and remain there till the close of the monsoon and therefore its utilization as a bait fish is restricted to the fag end of the tuna season.

Spratelloides japonicus (Houttuyn) from the Laccadive Sea (By Mr. K. L. K. Kesavan).

Examination of the recent fish collections from the Laccadive Sea has revealed the presence of *Spratelloides japonicus* (Houttuyn) from Minicoy where it appears to be much less abundant than its congener. Both the species have the same local name. Mr. Mohamed Sayeed, Field Assistant who recently collected fish specimens from a number of islands in the Laccadives, has informed me on enquiry that he has come across this fish at Chetlet and Kiltan where it is called *bayi-chala* (*bayi*=outer zone of the reef ; *chala*=sardine). There are however no samples of this fish in the collection brought by him.

S. japonicus has a fairly wide distribution in the Indo-Pacific and has been known from Red Sea, Indonesia, Philippines, Japan, Korea, Lord Howe Island and Polynesia (Fowler, 1941) and from Ceylon (Munro, 1955). This appears to be the first record of the fish from Indian waters.

A brief description of *S. japonicus* based on the material examined from the Laccadive Sea is given below and a specimen 52.7 mm. in length is figured here.

D. ii, 10-11 ; A. iii, 10 ; about 38 to 40 scales in lateral line + 3 or 4 scales at base of caudal, predorsal scales 12-13 ; gill rakers 12-15 + 24-28 on upper and lower limbs of the outer gill arch respectively. A few of the important body proportions expressed in thousandths of the standard length are as follows. Head 226-255 ; snout 79-93 ; diameter of eye 59-70 ; predorsal distance 461-495, and preanal distance 785-807 in standard length.

As both *S. delicatulus* (Bennett) and *S. japonicus* (Houttuyn) are known to occur in Indian waters, the following key is given to facilitate their field identification.*

(*a*) Sides of body with distinct silvery white lateral band ; total scales in latera line generally 40-44 ; anal with 13 rays.....*S. japonicus* (Houttuyn)

(*b*) Sides of body devoid of silvery white lateral band ; total scales on lateral line generaly 35-38 ; anal with 9 to 10 rays....*S. delicatulus* (Bennett)

Central Marine Fisheries' Research Station, Mandapam Camp. S. JONES

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* It may be mentioned in this connection that *Spratelloides malabaricus* (Day, 1873 *Proc. zool. Soc. Lond.*, 240 ; 1878, *Fishes of India*, 648, pl. CIXI, fig. 5) rightly belongs to the genus *Stolephorus* Lacépède and is therefore not included here.

THE STRANDING OF TWO FALSE KILLER WHALES [*PSEUDORCA CRASSIDENS* (OWEN)] AT POZHIKARA, NORTH OF CAPE COMORIN

ON 27 November 1960 the fishermen at Pozhikara, a fishing village between Cape Comorin and Colachel on the west coast were surprised to find two small whales in shallow water within a few metres from the shore. Some of the enterprising young men entered the water and tried to hold on to the tail of one of them, which excitement caused both animals to run ashore and get stranded. They were hauled to a small pool at the mouth of a narrow backwater canal near the shore. The event of the capture of such strange creatures which no one could recollect seeing along that coastal stretch atleast during the past three decades, received wide publicity in the local newspapers resulting in several hundreds of people visiting Pozhikara to view the animals.

The larger of the two measuring 375 cms. died one day later, most probably due to asphyxiation as the water was apparently not of sufficient depth to allow for

its free movement. On the 30th the carcass was gifted to the S.T. Hindu College, Nagercoil, and the preparation of the skeleton of it for display has been undertaken by one of us (C.K.P.). The second animal measuring 279 cms. lived for three days and on its death it was buried under some coconut palms as manure.

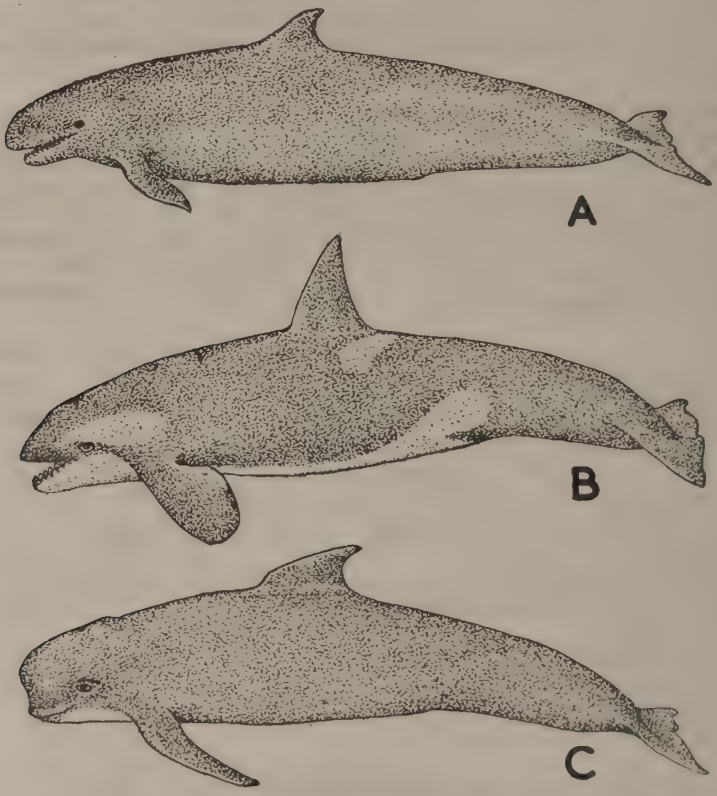
On 9 December, on hearing of these strandings one of us (E.G.S.) visited Pozhikara and through the kind help of Mr. M. G. Jayachandra, the owner of the coconut tope, the second specimen was exhumed and although decomposition had set in it was possible to identify the remains as belonging to a male False Killer Whale, *Pseudorca crassidens* (Owen) and retrieve the almost complete skeleton of the animal.

On the 10th we were also able to exhume the larger specimen buried at the S.T. Hindu College premises (for preparing the skeleton) and identify the remains as that of a female *P. crassidens*. In this animal the mammae in the inguinal region were conspicuously bulging owing to the bloating of that part of the body due to internal decomposition which had taken place to such an extent that it was not possible to verify whether it had any embryo or foetus within. Two photographs of the animal taken when the carcass was first brought to the College on 30th November are reproduced on plate I. A few measurements of both specimens taken on the 10th are given below.

	Male	*Female*
Total length to fork of tail ..	2790	3750 mm
Tip of snout to origin of dorsal fin ..	1200	—
,, ,, ,, ,, anal opening ..	—	2090
,, ,, ,, ,, eye ..	312	—
,, ,, ,, ,, angle of mouth ..	288	290
,, ,, ,, ,, anterior insertion of flipper ..	530	680
,, ,, ,, ,, blow-hole ..	356	—
Width of blow-hole ..	47	—
Length of flipper from anterior insertion to tip ..	340	380
Width of flipper ..	129	—
Eye to anterior insertion of flipper ..	215	370
Depth of body at anal opening ..	340	—
Depth of body mid-way between anal opening and base of caudal flukes ..	280	—
Anal opening to fork of caudal flukes ..	600	—
Length of one half of caudal fluke from fork ..	295	—
Anal opening to genital orifice ..	160	—
Length of contracted penis ..	175	—
Diameter of mammae at base ..	..	75
Distance separating the two mammae ..	..	70

The False Killer is a truly oceanic species with a cosmopolitan distribution. Only twice has it been reported from the Indian coast and the first record refers to a 513 cm. (16′ 10″) specimen stranded on 14 February, 1902 on the beach in the neighbourhood of Trivandrum (Ferguson and Lydekker, 1903). The second record refers to two immature specimens, a male and a female caught in fishing nets 10 miles north of Trivandrum (Dawson, 1911). The only other records of *P. crassidens* from this region are that of three schools stranded on the Ceylon coast reported by Pearson (1931) and Deraniyagala (1945). While its occurrence in these waters may be considered to be a rarity, one feature peculiar to the False Killer is its movements in large schools often numbering several hundreds and also its tendency to get stranded in such large numbers, several such strandings being listed by Fraser (1948). In this connection it may be interesting to mention here that on or about 27 November local newspapers reported two other strandings involving small sized

whales, one at Ovari on the east coast between Cape Comorin and Thiruchendur and the second a few miles north of Alleppey on the west coast. Although it has not been possible to verify the identity of the species involved in these two strandings, the incidents bear recording, if for nothing else, at least to draw attention to the strandings at three places of small-sized whales along a coastal stretch of about 300 Km. within a few days apart.



Drawings of (A) *Pseudorca crassidens* (Owen); (B) *Orcinus orca* (Linnaeus); and (C) *Globicephala melaena* (Traill) (After Fraser, 1948).

Previous strandings of the False Killer have shown notable differences in the sizes of the individuals constituting a school, but both the sexes have been noticed to occur in almost equal numbers, and as such the stranding of a male and female at Pozhikara may be only mere coincidence. There is no evidence of this species showing any periodicity of migration to inshore waters for breeding and it has been suggested that some of the mass strandings of the False Killer may be on account of changes in the distribution of water masses and consequently the alteration of the distribution of the animals on which they feed. Once getting close to the breaker-zone in the calmer inshore waters, they are liable to be stranded. The

Female False Killer Whale, *Pseudorca crassidens* (Owen) 375 cms long stranded at Pozhikara north of Cape Comorin.

size of the specimens indicate the male had not attained sexual maturity which the species is said to reach when it is 3.65 to 4.25 metres long (Fraser, 1948). The False Killer is not known to exceed six metres in length and the adult male is on the average about 60 cms. longer than the female.

Although distinct in several characteristics, *P. crassidens* is liable to be confused with two other smaller whales, namely, the Killer Whale *Orcinus orca* (Linnaeus), and the Indian Pilot Whale *Globicephala macrorhyncha* Gray, all belonging to the family Delphinidae, and have been reported from strandings from the Indian coast. The characters such as the robust body ; gently sloping snout which does not surpass the tip of the lower jaw ; paddle-like large flippers with rounded margins ; more or less high triangular dorsal fin ; and the marked colour of black and white belly, white patches one above eye on side of head and another behind base of dorsal on upper side of body of *O. orca*, and the conspicuously bulbous head and long tapering flipper which is about one-fifth to one-seventh the body length (*versus* one-eighth to one-tenth in *P. crassidens*) of *G. macrorhyncha* should help in easily distinguishing them from *P. crassidens*. Drawings of *P. crassidens*, *O. orca*, and *G. melaena*, the last closely allied to *G. macrorhyncha* are given in figure 1 to facilitate comparison.

This third definite record of the False Killer after a lapse of about 50 years not very distant from its first two recorded location on the Indian coast (Trivandrum is about 60 Km. north of Pozhikara) is of interest.

We take this opportunity to thank Mr. V. Paravaikkarasu Pillay and Mr. N. Sreenivasan of the S. T. Hindu College for the photographs reproduced here ; Mr. M. J. Jayachandra, Secretary, Fishermen's Co-operative Society, Pozhikara, and Messrs. Vincent, Charles A. Roach, and Peter of Pozhikara for the gift of the specimens and for help in the field.

Central Marine Fisheries Research Station, E. G. Silas
Mandapam Camp, and S.T. Hindu College, Nagercoil. C. Kumara Pillay

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NEWS AND COMMENTS

Exploration of the Sea—Conference at Moscow

The 48th annual meeting of the International Council for the Exploration of the Sea was held at Moscow during September 1960. More than two hundred papers were presented covering a wide range of subjects including work on herring, salmon and trout, cod, mackerel and tuna, shell fish of different kinds, plankton and gear. The Council's main function is to promote and coordinate the fisheries research of the countries interested in fisheries of the N.E. Atlantic and adjacent areas.

Interstate Fisheries Conference

The 1960 conference of Commonwealth and State Fisheries officers which took place in Canberra in September 1960 has undertaken definite steps towards the establishment of an Australian Fisheries Council and the provision of training for inspectors and fishermen. The CSIRO Marine Laboratory at Cronulla has been recommended as the venue for the training course. The conference, among other things, urged the necessity for speeding up research on the stocks of pelagic fishes such as tuna, in the south-eastern Australian waters, and also reaffirmed its earlier opposition to the introduction of exotic food fishes.

Ocean Forecasts

Dr. John Tully, head of the Pacific Oceanographic Group at Nanaimo (B.C.), told the Fisheries Council of Canada Convention that ' soon we will be able to tell nine months ahead what ocean currents are going to do, ... We can now estimate salinity and actually tell temperatures, from aircraft. Within a few years we will be able to map the currents from information gained by aerial observation, and this will be the basis of long-range forecasts of currents and fish movements.'

Crayfish Regulations

Tasmanian Sea Fisheries Regulations have been amended to define the closed season against the taking, trading in, or possession of female crayfish as being from June 1 to October 31 (instead of November 30) annually. The same closed season operates in Victorian waters and in the commonwealth waters adjacent to Victoria and Tasmania.

With the recent increased activity in spiny lobster fishery and reported gradual fall in yield over these few years along the south-west coast of Peninsular India we seem to be faced with a serious problem. It appears that the lobster fishery in this part of the coast in our country needs immediate attention.

Fish from the Depths

Biologists working from the Soviet Research Vessel *Vityaz* have recently obtained a hitherto unknown fish from a depth of 7,580 metres in the Kurile-Kamchatka depression in the Pacific. Notable peculiarities of the fish are a nearly colourless body without scales and tiny jelly-like eyes. This unique fish is at present in the Zoological Institute of Leningrad.

New Journal on Marine Molluscs

Indo-Pacific Mollusca is a new taxonomic journal devoted to the speciation, identification and geographical distribution of the marine mollusca of the Indian and tropical Pacific Oceans. Each number, published as research is completed, covers all the known Recent and Tertiary species of a genus or family, and includes full synonymies, full descriptions, types, ranges, locality records, comparative remarks, and a condensation of anatomical, ecological and economic information.

The journal is being published from the Department of Mollusks, Academy of Natural Sciences, 19th & The Parkway, Philadelphia 3, Pa., U.S.A.

THE SNORKEL LEAGUE

The latter half of 1960 was a relatively slack season for the Snorkel League. With turbulent conditions prevailing in Palk Bay and frequent showers and gusty wind, the Leaguers had to restrict their activities to the Gulf of Mannar. When the weather conditions permitted the Leaguers went out for snorkeling at Vethālai. Though this place does not offer the variegated splendour and charm of a submerged coral reef, it is a fertile ground for making general marine biological collections of star fishes, sea cucumbers, sea lilies and the like. The hiding places of juvenile lobsters were discovered and several specimens were successfully collected. Interesting observations on certain animal associations were also made.

As usual, many distinguished visitors to the headquarters of the Marine Biological Association evinced keen interest in the activities of the Snorkel League. Dr. David Cecil Rife, Scientific attaché to the United States Embassy and Mrs. Cecil Rife went out for frequent snorkeling during their brief stay here. Col. G. V. Raja from Trivandrum was another distinguished guest who was fascinated by this underwater sport. Being the President of the Kerala Aquatic Association, he wants to popularise skin diving in Kerala which has many natural facilities. The Snorkel League has managed to supply some masks, snorkels and swim fins to the Aquatic Association as per his request. It is hoped that under the aegis of Col. G. V. Raja, who himself is a good sportsman, this comparatively young sport with its vast scientific scope for aquatic biologists would soon become popular in Kerala.

The post-graduate students from the Madras University who were here on a study tour made much use of the facilities rendered by the Snorkel League in making their collections and ecological observations.

A season of intense activity is expected for the Snorkel League in the forthcoming period, with a regatta and aquatic sports planned to be held early next year. The turbid waters of Palk Bay turning clear and calm in the following months would add a new fillip to the enthusiasm. Many new members have already procured additional sets of mask and snorkel. With not much dearth of diving kit and an inviting sea around, it is hoped that the Snorkel League would have another fruitful season in the months ahead.

CONVENER.

ANNUAL REPORT OF THE MARINE BIOLOGICAL ASSOCIATION OF INDIA FOR THE YEAR ENDING 1960

Mr. President and fellow members of the Association :

It is my pleasant duty to-day to present the second Annual Report of the Marine Biological Association of India. Since we met last in December 1959 the Association has made rapid progress in its various activities.

I am glad to inform you that His Excellency the Governor of Madras was kind enough to accept our invitation to be a Patron-in-Chief and the Vice-Chancellor of the Kerala University to be one of the Patrons. I am also glad to announce the generous donation of Rs. 500.00 given by the Indo-Norwegian Foundation.

Since the membership forms reached many people, particularly those abroad, very late, the Association received numerous requests after December 1959 to enroll members, both individual and institutional, as Foundation Members. The Executive Council, therefore, resolved that the Foundation Membership be kept open until December 1960 and that this be ratified by the General Body at its next meeting. I would request that this be done. The total membership of the Association stands at 702 as on 31-12-1960. Of these 10 are Life members and 141 Institutional. The position is somewhat reassuring and it is earnestly hoped that the Association will continue to get increasing support both from individuals and institutions in India and abroad.

Dr. Roger Revelle of the Scripps Institution of Oceanography was elected as a Corresponding Member of the Association. Dr. S. V. Job, the Managing Editor, had to leave the Headquarters of the Association to take up his new appointment and consequently he relinquished his office with effect from 13-6-1960. I take this opportunity to place on record our sincere gratitude to him for his valuable services to the Association. Sri P. R. S. Tampi was nominated to succeed Dr. Job. Sri S. Mahadevan was nominated as the Assistant Treasurer.

The following is a brief account of the activities of the Association during the year 1960.

10 meetings were held at the Headquarters of which two were under the joint auspices of the Zoological Society of India, Mandapam branch and the Marine Biological Association of India. These meetings were largely attended and were followed by lively discussions.

The Snorkel League of the Association had a fine spell of activity. The members went for frequent snorkeling to Palk Bay, Rameswaram Reef and other nearby areas. Many distinguished visitors to this locality also evinced keen interest in snorkeling. An important landmark in the activities of the League was an Aquatic Sports Meet held on May 28, 1960. On the transfer of Sri K. M. Gopal, Sri P. V. Ramachandran Nair was elected as the Convener.

A local branch of the Association was formed at Mangalore and in anticipation of the approval of the Executive Council one more branch has been provisionally formed at Tuticorin. This brings the total number of local branches to 4.

With the approval of the Executive Council a separate Dugong Research and Conservation Fund was started.

The Marine Biological Home at Pamban has been very popular. 31 parties consisting of 652 students and 76 staff members availed of the facilities of the Home.

It should be regretfully admitted that in spite of all efforts it was not possible to bring out Vol. II of the Journal during 1960. The Managing Editor will be presenting shortly a detailed report on the publications of the Association.

The audited statement of accounts is already with the members. In the absence of the Treasurer, the Assistant Treasurer will be formally presenting the Balance Sheet.

Before I place this report for your approval, let me take this opportunity, on behalf of the office bearers of the Association and on my own behalf, to thank all members for their unfailing support and co-operation in the healthy functioning of the Association. Finally in my capacity as Resident Secretary, I would like to express my gratitude to the President and other members of the Executive Council and the Associate office bearers for their whole-hearted co-operation and unstinted help.

Thank you all.

Confirmed

(Sd.) S. Jones,
(President).
4-2-1961.

(Sd.) R. Raghu Prasad,
(Resident Secretary).

TREASURER'S REPORT

Mr. President and fellow members of the Association :

In the absence of the Treasurer, Shri K. Virabhadra Rao, the duty of presenting the accounts of the Association for 1960 has fallen on my shoulders. However, the task has been rendered relatively easy since he had kept ready all the accounts up to date for the audit. The audited statement of accounts is presented here and is mostly self-explanatory.

The income for the Association for the year 1960, excluding casual items, amounts to Rs. 7,955.19 as against Rs. 5,082.52 for 1959. During the year we incurred an expenditure of Rs. 3,878.15 for printing Vol. I (2) of the Journal and we have to meet the cost of printing Vol. II, Nos. 1 & 2 also for the year, approximately costing us Rs. 7,800.00. There is thus a deficit of about Rs. 6,000.00. This deficit is unavoidable in spite of the fact that we have been frugal in many items of expenditure. We have to find ways and means of wiping out this deficit and for this I invite suggestions from the members. The collection of arrears of subscription and sale of journals, will, to a certain extent, cover this deficit.

At the end of 1960 the register shows a total of 702 members. Of these 190 Indian members and 76 foreign members are yet to renew their membership for 1960. I appeal to them to renew their membership soon and thus play their part in improving the finances of the Association.

The Association wishes to place on record its hearty thanks to the Indo-Norwegian Project for their donation of Rs. 500.00.

I wish to thank Sri S. K. Srinivasan, Chartered Accountant, for auditing the accounts of the Association even though the notice given to him was very short. I also thank Sri S. Rajagopalan, for his valuable help in scrutinising the accounts at great personal inconvenience, and Sri P. S. Sadasiva Sarma for all help rendered from time to time.

Thank you all.

Confirmed

(Sd.) S. Jones,
(President)

(Sd.) S. Mahadevan,
(Asst. Treasurer)

4-2-1961.

MARINE BIOLOGICAL ASSOCIATION OF INDIA

Income and Expenditure Account for the year ended the 31st December, 1960

EXPENDITURE	Rs. nP.	Rs. nP.	INCOME	Rs. nP.
To Expenses paid :—			By Entrance fees received	832.50
Printing and Stationery ..	784.94		By Subscription received	7,955.19
Postage	838.39		By Advertisement charges in the Journal	143.22
Bank commission	131.22		By Bank Interest	19.34
Miscellaneous	352.49			
		2,107.04	By Sale of reprints and publications ..	578.92
To Charges paid for printing Journal Vol. I (No. 2)		3,878.15	By Donations during the year ..	500.00
				10,029.71
To Charges for reprinting Vol. I (No. 1) ..		1,841.62		
To Cost of reprints		486.79	By Excess of expenditure over income.. ..	6,084.43
To Charges for printing Vol. II (No. 1) as provided for on estimate		3,900.00		
To Charges for printing Vol. II (No. 2) 1960 as provided for on estimate.. ..		3,900.00		
Total ..		16,113.60	Total ..	16,113.60

Accounts Checked by

S. RAJAGOPALAN
Member
20-3-1961

Examined and found correct

(Sd.) S. K. SRINIVASAN
Chartered Accountant

Accounts presented by

(Sd.) K. VIRABHADRA RAO
Treasurer

MARINE BIOLOGICAL ASSOCIATION OF INDIA

Receipts and Payments Account for the year ended the 31st December, 1960

RECEIPTS	Rs. nP.	Rs. nP.	PAYMENTS	Rs. nP.	Rs. nP.
To Balance of as on 31-12-1959 as per previous statement		2,880.18	By Expenses Paid :—		
To Entrance fees received		832.50	Printing & Stationery	784.94	
To Subscriptions received :—			Postage	838.39	
Life Members	612.10		Bank Commission	131.22	
Ordinary Members	7,343.09		Miscellaneous	352.49	
		7,955.19			2,107.04
To Advertisement charges in the Journal ..		143.22	By Charges paid for printing of Journal Vol. I, No. 2 (including cost of blocks)		3,878.15
To Sale of Publications and reprints ..		578.92	By reprinting of Vol. I, No. 1		1,841.62
To Donations received		500.00	By cost of Reprints		486.79
To Bank Interest		19.34	Fixed Deposit with State Bank of India, Ramnad		1,000.00
			By balance of cash on 31-12-60 :—		
			With State Bank of India, Ramnad..	2,891.88	
			With Lloyds Bank, Madras ..	436.08	
			With office bearers on advance accounts	48.32	
			With the Treasurer	219.47	
					3,595.75
Total ..		12,909.35	Total..		12,909.35

Accounts Checked by
S. RAJAGOPALAN
Member.

Accounts presented by
K. VIRABHADRA RAO
Treasurer.

I have examined the above Receipts and Payments Account with the books of Account, Counterfoils of Receipt books and Vouchers produced to me and obtained all the information and explanations required. I am satisfied that all the Receipts and Payments for the period under review are correctly recorded.

I certify that, to the best of my knowledge and belief, the aforesaid account is true and correct.

20-3-1961.

(Sd.) S. K. SRINIVASAN,
Chartered Accountant.

REPORT OF THE MANAGING EDITOR

Mr. President and members of the Association :

In the absence of both the Editor and the Joint Editor, I have the honour to present to you the Annual Report for 1960 relating to the Journal of the Marine Biological Association of India.

Volume I, No. 2 of the Journal was issued early in September 1960. A total of 1250 copies were printed at a cost of Rs. 3,878.15. Since the publication of the first number of Vol. I there has been an enormous increase in the membership and requests for the Journal have been steadily mounting, with the result, the initial set went out of print. In order to cope up with the increasing demand another 750 copies of this number had to be reprinted at a cost of Rs. 1,841.62. Copies were ready by October 1960. It is encouraging to mention here that most of the individuals and institutions who are becoming members of the Association even now are requesting for the back numbers of the Journal. The additional expenditure incurred on this account thus seems well justified.

While it is gratifying to find that the Journal is continuing to receive wide appreciation by the scientific public, it has to be regretfully admitted that despite all our efforts, we have not been able to bring out the volume for 1960 according to our time schedule. The first number of Volume II is getting ready for release and will soon be followed by the second number. We assure the members that every possible effort is being made to make up for this hitherto unavoidable delay in publication. In this connection I wish to thank the Diocesan Press, Madras, for their excellent workmanship in the printing of the Journal.

To the authors of the numerous articles that appeared in the Journal and to the many industrial concerns who have chosen our Journal as the medium for advertising their products I wish to express our thanks.

Thank you all.

Confirmed

(Sd.) S. Jones,
(*President*)

(Sd.) P. R. Sadasivan Tampi,
(*Managing Editor*)

Mandapam Camp.

Feb. 4, 1961.

ADDITIONAL LIST OF MEMBERS*

AHMED, V., Akkiveedu, W. Godavari.
ALAGARAJA. K., Central Inland Fisheries Research Station. Barrackpore.
ALOYSIUS. Rev. P.. University Zoological Laboratory, Madras-5.
ANANDAM, (Miss), A., Providence Women's College, Kozhikode.
ANWER, S.S. M. Md., Tondi, Ramnad District.
APPUKUTTAN. N., Central Fisheries Technological Research Station, Cochin-5.
ARISOY, Dr. SULAIMAN, T. C. Ziraat, Bankasi, Ankara, Turkey.

BERLIN, O. G., American College, Madurai.
BHANUMATHI (Mrs.). P. A.. Department of Zoology. Presidency College, Madras-5.
BHARATWAJ, Lt.-Col., Indian Navy, Apollo Bunder, Bombay-1.
BIERI. Dr. R.. Yellow Springs. Ohio. U.S.A.
BORGSTROM. Prof. GEORG. Michigan State University. East Lansing. U.S.A.
BRYANT, (Miss) MARY, T., University of Liberia, Monrovia, Liberia.
BUCH, A. C., Gandhinagar, Madras-20.
BUTCHER, A. W., Three Salmons, USK, Mon., Wales.

CHAKRABORTI, DEBIDOS, Central Marine Fisheries Research Station, Mandapam Camp.
CHIDAMBARAMIER, P., R. R. Stall, Pamban.
CHIN PHIN KONG. Dr., Fisheries Officer, Jesselton. Colony of North Borneo.
CLOUD, Dr. P. E. Jr., Geological Survey. Washington 25, D.C., U.S.A.
CONARD, W. K., Everglades. Florida. U.S.A.
CROOK, Rev. Dr. D. A., Old Dindigul Road, Madurai.

DANDAPANI, P., Victoria Hostel, Madras-5.
DATTA, A., Central Inland Fisheries Research Station, Barrackpore.
DESAI, B. N., Taraporewala Aquarium, Bombay-2.
DEVARAJ, Wesley Hostel, Royapettah, Madras-14.
DORAIRAJ, G., Annamalai University, Annamalainagar.

FRANCA PEDRO Da. Dr., Centrode Biologa Piscatoria. 9-Lisboa-1.
FREEMAN, Dr. J. A., Winthrop College, Rock Hill. S. Carolina. U.S.A.

GHOSH. K. K., Central Inland Fisheries Research Station. Barrackpore.
GILBERT. Dr. P. W.. Cornell University. Ithaca. New York. U.S.A.
GOWRI PARVATI BAI, (Miss)., Kowdiar Palace, Trivandrum-3.

HITHAYATHULLAH, B., Panaikulam, Ramnad District.

INDRASENAN. A., University Zoological Laboratory. Madras-5.
ISKANDER, Dr. M., Nicola Iolidis, Shoubra, Cairo, U.A.R.

JAMES, A., Fisheries Technological Station, Tuticorin.
JAYACHANDRAN. P., Fisheries Technological Station. Tuticorin.
JHINGRAN, Dr. V. G., Central Inland Fisheries Research Station Unit, Balugan, Orissa.

---

* Since the list published in Vol. 1, No. 2, 1959, of this Journal.

John, C. L., Bombay Fisheries Department, Veraval, Saurashtra.
Jose, Joseph, Department of Zoology, Mar Ivanios College, Trivandrum-4.

Krishnamoorthi, N., Industrial Chemicals, Tinnevelly Dt.

Macnae, Dr. William., University of Witwaterstrand, Johannesburg.
Mackay, Dr. M. M., Lonavelle, N.W.S., Australia.
Madhavi, (Miss) R., Andhra University, Waltair.
Malhotra, J. C., Central Inland Fisheries Research Station, Barrackpore.
Maraicayer, M. A. M. Md. Abdul Kader, Mandapam.
Marinus, Rev. P., St. Joseph's College, Calicut.
Mathew, (Miss) S. Molly, Women's College, Trivandrum.
Mekhala, (Miss) A. G., Fisheries Technological Station, Tuticorin.
Mital, P. L., Government College, Ajmer, Rajasthan.
Mito, Dr. Satoshi., University of Kyushu, Fukoka, Japan.
Mohamed, S. K. V. Z. Varvsai, Kilakarai, Ramnad District.
Mohan, S. L., Central Inland Fisheries Research Station, Barrackpore.
Mukundan, A., Krishna Baug, Chembur, Bombay-71.
Murugesan, M., Marine Fisheries P.O., Mandapam Camp.

Nair, S. G. K., Inbios, George Town, Madras-1.
Nimbalkar, P. K., Central Inland Fisheries Research Station, Barrackpore.

Panicker, G. C., Central Inland Fisheries Research Station, Barrackpore.
Pantulu, V. R., Central Inland Fisheries Research Station, Barrackpore.
Pillai, M. K., Inbios, George Town, Madras-1.
Pillai, C. Kumara, S. D. College, Nagercoil.
Pillai, C. Malu, Marine Biological Station, Tuticorin.
Pillai, Paravaikarasu, S. D. College, Nagercoil.
Pillai, U. Somasundaram, Mylapore, Madras-4.
Prabhakar, E. C. P., Collector of Ramanathapuram at Madurai, Madurai.
Premkumar, V. K., Zoological Survey of India, Calcutta-12.

Quadir, T. S. O., Abdul, K.T.M.T.M. & Co., Kilakarai, Ramnad District.

Raja, Lt.-Col. G. V., Kowdiar Palace, Trivandrum-3.
Ramakrishnan, C. P., R.R. Stall, Pamban.
Rao, B. Ramajogeswara, Bandhakari House, W. Godavari.
Rao, T. Ramakrishna, Central Marine Fisheries Research Station, Mandapam Camp.
Rao, Santharama, Government College, Mangalore.
Rao, I. Seshagiri, Daba Gardens, Visakhapatnam.
Rao, K. Subba, S.M. Board High School, Tondi, Ramnad District.
Rao, K. Subba, Central Inland Fisheries Research Station, Barrackpore.
Reddiah, Dr. K., Zoological Survey of India, Shillong, Assam.
Rema Devi, (Miss) N., Presidency College Women's Hostel, Madras-5.
Rife, Dr. David C., American Embassy, New Delhi-21.
Roche Victoria, Chev. J.L.P., Sukhasthan, Tuticorin.
Root, S. E., Kodaikanal School, Kodaikanal.

Sambandamurthy, P. S., Aras Gardens, Monacaud, Trivandrum.
Sankunni, C. Kumarath, State Port Office, Madras.
Saraswathy, (Miss) M., Marine Biological Laboratory, Trivandrum-7.

SARASWATHI SANKARAN, (Miss)., Vadukar Road, Mylapore, Madras-4.
SARMA, P. S. SADASIVA, Central Marine Fisheries Research Station, Mandapam Camp.
SAWANT, P. L., Dalas House, Ash Lane, Bombay-28.
SEBASTIAN, M. J., Central Marine Fisheries Research Centre, Neendakarai, Kerala.
SHAH, K. P., Jawahar Nagar, Ahmedabad-7.
SHANTHAKUMARI, (Miss) K., Department of Zoology, Andhra University, Waltair.
SHOJIAMA, Dr. YOICHI, Seikai Regional Fisheries Research Laboratory, Nagasaki City, Japan.
SIVAPRAKASAM, T. E., Central Marine Fisheries Research Station, Mandapam Camp.
SMITH, Dr. EDMUND H., Friar Street, Woodland Hills, California, U.S.A.
SOLOMON RAJU, N., Department of Zoology, Andhra University, Waltair.
SONPAR, V. N., Com. I. N., Naval Office, Fort St. George, Madras-9.
SOUNDARARAJAN, S., 82-C Mount Road, Madras-18.
SOUTHWARD, Dr. E. C., The Laboratory, Citadel Hill, Plymouth, U.K.
SUBRAHMANYAM, R., Burmah Shell, P.B. 129, Madurai.
SZELA, Dr. TADEUSZ KAROL, Kettering, Northants, England.

TAIT, Dr. R. V., Nightingale Road, Rickman's Worth, Herts, England.
TARE, M. M., Eastern Shipping Co. Ltd., Calcutta-13.
THIAGARAJAN, S., District National Savings Organiser, Virudunagar.
TOOR, HARDEV SINGH, Central Marine Fisheries Research Station, Mandapam Camp.
TRIPATHI, S. D., Central Inland Fisheries Research Station, Barrackpore.

UNNITHAN, R. V., Mohanlands, Trivandrum-1.

VANAJAKSHI, (Miss) M. N., Presidency College Women's Hostel, Madras-5.
VARGAS, PETER ANTHONY, San Bernardino, California, U.S.A.
VASANTHA, (Miss) T. V., 1st Main Road, Raja Annamalaipuram, Madras-28.
VENKATARAMIAH, A., Andhra Loyola College, Gunadala Post.
VIRAY, V. F., Sinal, Pangasinan, Philippines.
VISWAMITRA, Department of Fisheries, Port Blair, Andaman Is.

WALKDEN, Dr. R., Dominion Street, Walney Is., Lancashire, U.K.

INSTITUTIONAL MEMBERS

AGRA COLLEGE GENERAL LIBRARY, Agra College, Agra.
ANDHRA LOYOLA COLLEGE, Gunadala Post. A.P.
AUSTRALIAN MUSEUM, College Street, Sydney, N.S.W.

BALFOUR LIBRARY, Cambridge, England.
BHAVAN'S COLLEGE, Andheri, Bombay-58.
BIBLIOTHEQUE DE L'UNIVERSITÉ DE PARIS A LA SORBONNE, Paris 5e, France.

CALIFORNIA INSTITUTE OF TECHNOLOGY, Pasadena, California, U.S.A.
CENTRAL BOARD OF GEOPHYSICS, Calcutta-16.
CENTRAL INLAND FISHERIES RESEARCH STATION, Barrackpore, *via* Calcutta.
CENTRAL MARINE FISHERIES RESEARCH SUB-STATION, Kozhikode-5.
CENTRAL SALT RESEARCH INSTITUTE, Bhavanagar.
CORONET CANNING COMPANY, Malpe.

Danmarks Fiskeri ϕg Havundersϕgelser, Charlottenlund Slot, Denmark.
Department of the Interior, Fiscal Section, Washington 25, D.C., U.S.A.
Department of Research and Education, Chesapeake Biological Lab., Solomons, Md., U.S.A.
Director of Fisheries, Government of Gujerat, Ahmedabad.
Le Directeur de Institut Francais de Oceanic Anse, Vata Naumea, New Caledonia.
Division of Fisheries, C.S.I.R.O., Cronulla, N.S.W.

Fisheries Research Board of Canada, Biological Station, Nanaimo, B.C., Canada.
Florida State Board of Conservation, Marine Laboratory Library, St. Petersburg, Fla. U.S.A.

Hydrographer, U.S. Navy Hydrographic Office, Washington 25, D.C., U.S.A.

Information Department, Pondicherry.
Institute of Oceanography de Monaco, Museum de Monaco, Monaco.
International North Pacific Fisheries Commission, Vancouver, B.C., Canada.

M. N. U. Jayaraj Nadar High School, Nagamalai.

Kanyakubja College, Lucknow.
Kerala Aquatic Association, Trivandrum.

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Little Flower College, Guruvayur, Kerala.

Mar Ivanios College, Department of Zoology, Trivandrum.
Marine Biological Station, Port Erin, U.K.
The Mauritius Institute, Port Louis, Mauritius.
Moskovskojc Otdeliniie Biblioteki Akademii Nouk, Moscow, U.S.S.R.
Ministry of Agriculture, Fisheries & Food, Fisheries Laboratory, Lowestoft, England.
Ministère des Pecheries, Grande-Riviire, Sud Quebec.
Museum of Comparative Zoology, Harvard, Cambridge, Mass., U.S.A.

N. Wadia College, Poona-1.
New India Fisheries Limited, Taiyo House, Bombay-5.
New York Zoological Society, New York, U.S.A.

Rhode Island University Library, Rhode Island, U.S.A.

Science Librarian, University College of North Wales, Bangor, Caerns, Wales, U.K.
The Science Library, Science Museum, S. Kensington, London, S.W.-7.
Scientific & Technical Documentation Division, National Research Centre, Dokki, Cairo, U.A.R.
Serials Acquisition Library, University of Texas, Austin 12, Texas, U.S.A.
South Pacific Commission, P.B. 9, Noumea, New Caledonia.

St. Agnes College for Women, Mangalore-2.
St. Columbus College, Department of Zoology, Hazaribag, Bihar.
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Station de Biologie Marine, Gaspe-Sud, Quebec, Canada.

Tropical Fish Culture Research Institute, Malacca, Federation of Malaya.
Tulane University Library, New Orleans 18, Louisiana, U.S.A.

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University of Auckland, Auckland, G.I., New Zealand.
University of California, Berkeley 4, California, U.S.A.
University of Hawaii, Honolulu, Hawaii, U.S.A.
University of Malaya, Singapore-10.
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BOOK REVIEW

CURRENT BIBLIOGRAPHY FOR AQUATIC SCIENCES AND FISHERIES, Vol. 3 Part I, compiled by F.A.O. Fishery Biology Branch. (Taylor & Francis Ltd., London, 1960 : pp. iv+88+96). Price 17*s.* 6*d.*

The Fishery Biology Branch of the FAO has brought out this year (1960) beginning with Volume 3 (to be issued in 12 parts to a volume) the ' Current Bibliography for Aquatic Sciences and Fisheries ' in the printed form for general distribution on a subscription basis. This publication is a continuation of the ' Current Bibliography for Fisheries Science ' Volumes I and II of which were issued in a mimeographed form in 1958 and 1959. In the announcement by the publishers it is stated that the manuscript lists are ' still prepared primarily as a document for internal use by the FAO ' and permission for their issue in the printed form had to be given in view of the heavy demand from research workers and libraries.

The first 88 pages of Part I of Volume 3 of the ' *Current Bibliography* ' which is under review are taken up by explanation of coverage and arrangement, consolidating the ' Explanatory Notes ' issued in the two preceding mimeographed volumes. These are followed by 98 pages of 628 references relating to studies of aquatic fauna and flora and their environment and methods of research pertaining to them. Each reference is followed by a brief abstract. As could naturally be expected the bibliography is comprehensive in the field of fisheries science.

The system of accession in the bibliography being not in the alphabetical order and absence of an index in the part under review might create some initial difficulties but these drawbacks are expected to be obviated in the future issues as and when improvements are effected and with the publication of an annual index. Larger circulation could probably be ensured if the price which is on the high side now could be brought down to come within the reach of ordinary research workers.

The Fisheries Branch of the FAO deserves to be congratulated for bringing out such an useful publication which could be recommended for reference purposes by fishery scientists and workers in the field of aquatic sciences. It will be a valuable acquisition for any library or institute catering to the needs of workers in the above disciplines.

S. JONES

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2. Brunton & Company, Engineers Ltd., Cochin-1. v
3. India Biological Products vii
4. Instruments and Equipments, 35-Chittaranjan Ave., Calcutta-12. ii
5. Mohamed Meerasha Maraicayer, K. S. M., Pamban, Ramnad Dist. .. ii
6. Nippon Gyomo Sengu Kaisha Ltd., Tokyo, Japan vi
7. Ogawa Seiki Co. Ltd., No. 184, 2-Chome, Hyakunin-cho, Shinjuku-ku, Tokyo, Japan vii
8. Porlester Ltd., Peckleton Common, Earl Shilton, Leichester, U.K. .. iii
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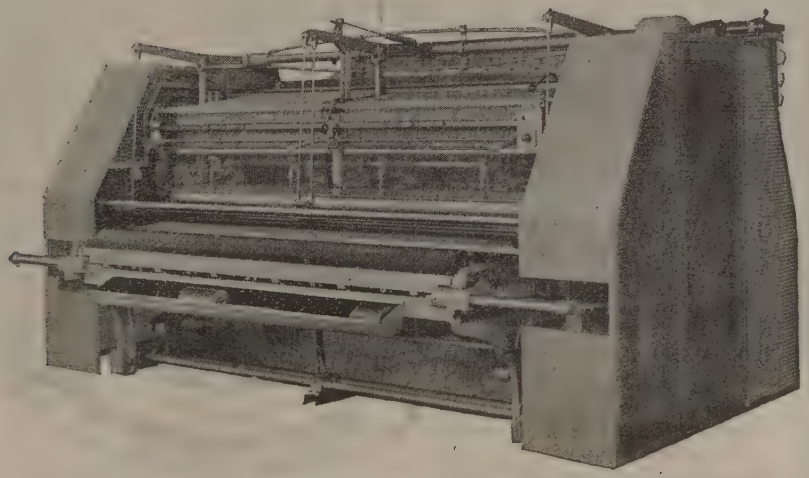

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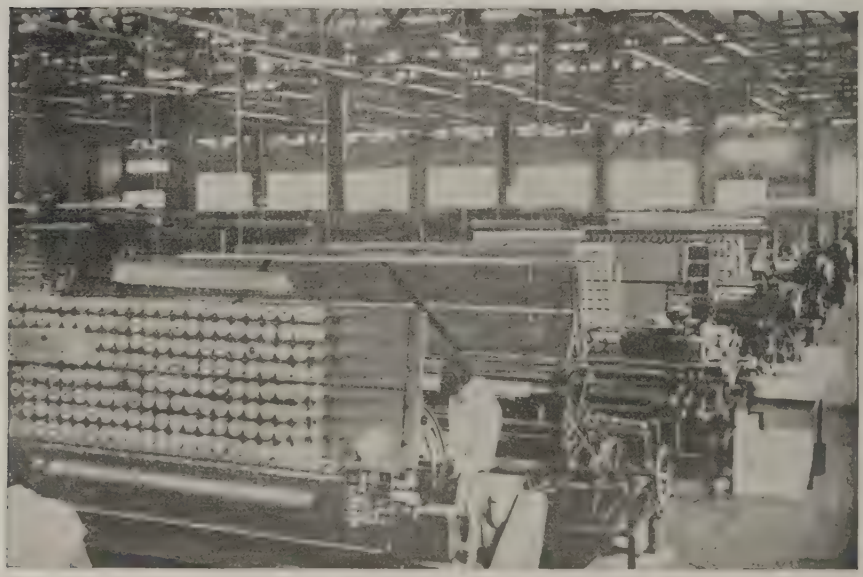

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CONTENTS

UMMERKUTTY, A.N.P. Studies on Indian Copepods 2. An account of the morphology and life history of a Harpacticoid Copepod, *Tisbintra jonesi*, sp. nov. from the Gulf of Mannar 149

UMMERKUTTY, A.N.P. Studies on Indian Copepods 3. *Nearchinotodelphys indicus*, a new genus and species of Archinotodelphyid Copepod from Indian seas. 165

UMMERKUTTY, A.N.P. Studies on Indian Copepods 4. Description of the female and a redescription of the male of *Pesudodiaptomus ardjuna* Brehm (Copepoda, Calanoida) with notes on the distribution and affinities of the species 179

SRINIVASAN, V.V. Ciliary currents and associated organs of *Martesia fragilis*, a wood boring pholad of Madras 186

JONES, S and SANKARANKUTTY, C. Notes on animal associations 3. A Parthenopid crab, *Harrovia albolineata* Adams and White on a Mariametrid Crinoid, *Lamprometra* sp. .. 194

RAMACHANDRAN NAIR, P.V. On two diatoms from the inshore waters of Palk Bay .. 196

RAMAMIRTHAM, C.P. AND JAYARAMAN, R. Hydrographical features of the continental shelf waters off Cochin during the years 1958 and 1959 199

GEORGE, K.C. On a new Gastrocotylid Trematode, *Engraulicola forcipopenis* gen *et* sp. nov. on White-bait, from Southern India. 208

BALAKRISHNAN NAIR, N. Rate of growth of *Bankia indica* Nair, a shipworm from the Madras Coast 216

PRASANNA VARMA, R. Flora of the pearl beds off Tuticorin 221

SRIDHARAN PILLAI. R. Studies on the Shrimp *Caridina laevis* (Heller) II. The reproductive system 226

SILAS, E.G. AND SANKARANKUTTY, C. On the castle building habit of the crab *Cardisoma carnifex* (Herbst) (Family Geocarcinidae), of the Andaman Islands 237

RAGHU PRASAD, R. AND TAMPI, P.R.S. Phyllosomas of scyllarid lobsters from the Arabian Sea 241

RAGHU PRASAD, R. AND TAMPI, P.R.S. On the newly hatched Phyllosoma of *Scyllarus sordidus* (Stimpson) 250

JAMES, P.S.B.R. Instances of excessive thickening of certain bones in the Ribbon fish, *Trichiurus lepturus* Linnaeus 253

ANDREW PACKARD. Marine Biological and Oceanographic Institutions of the world. 4. The Naples Zoological Station 259

NOTES :

NAGABHUSHANAM, A.K. Observations on some pela ic tunicates in coastal waters of the Bay of Bengal, 263. BALASUBRAHMANYAM, K. *Cossura delta* Reish (Polychaeta) from the Vellar estuary, 264. INDRASENAN, A. On the occurrence of the platacid fish *Tripterodon orbis* Playfair in Indian waters, 266. JONES, S. Further notes on *Spratelloides delicatulus* (Bennett) as a tuna live-bait fish with a record of *S. japonicus* (Houttuyn) from the Laccadive sea, 267. SILAS, E.G. AND KUMARA PILLAY. The stranding of two false killer whales [*Pseudorca crassidens* (Owen)] at Pozhikara, north of Cape Comorin, 268.

NEWS AND COMMENTS 272

ANNUAL REPORT OF THE MARINE BIOLOGICAL ASSOCIATION OF INDIA 275

Secretary's Report 275

Treasurer's Report 277

Managing Editor's Report 280

ADDITIONAL LIST OF MEMBERS 281

BOOK REVIEW 286

On the front cover page is shown the Marine Survey ship *INVESTIGATOR* which carried on pioneer oceanographic investigation in Indian waters.